BIG BILL

The Williamson River Basin Watershed Analysis

Chiloquin and Chemult Ranger Districts

Winema National Forest

February 1998

WATERSHED ANALYSIS TEAM

The following persons were assigned the task of gathering available information, researching local knowledge of the watersheds through local publics, and evaluating conditions on-site. Together, as a team, they have worked to assimilate the information necessary to prepare this report.

Elizabeth Budy, S.O. Archaeology	History, Human Uses
Richard Howard, Chiloquin R.D.	Range, Wildlife, Soils
Bradley Kerr, S.O., Ecosystem Mgt.	Fish Biology, Water Quality
Mike McNeil, S.O. Ecosystem Mgt.	Hydrology, Geology, Climate
Eric Nicita, S.O., Ecosystem Mgt.	Soils
Leslie Sekavec, S.O., Ecosystem Mgt.	Vegetation, Silviculture
Tim Sexton, Chiloquin R.D.	Fire Ecology
Ken Van Zee, S.O. Ecosystem Mgt.	Team Leader, Writer/Editor
Elizabeth Williams, Chemult R.D.	GIS/Database Mgt.

Special thanks to the following individuals for their assistance, input or technical knowledge. Their contributions helped make this report possible.

Kent Russell, Chiloquin District Ranger, for developing the issues, and his unending support.
Jack Sheehan, S.O. EM Staff, for his divine leadership, endless patience, and last but not least, the $$.
Steve Trulove, Chiloquin R.D., for helping with GIS work.
Tuffy Eggsman, Chiloquin R.D., ditto.
Wanda Bennett, S.O., also for assisting with GIS work.
The print shop team, for the professional copy and publishing work.

There are no doubt some that I forgot, but thanks to all that helped.

INTRODUCTION

The intent of this assessment is to provide a general description of ecosystem structure, processes, and functions occurring within the Williamson River Basin Watershed. The analysis area includes 533,572 acres of Winema National Forest land, 37,906 acres administered by the US Fish and Wildlife Service, 51,674 acres of National Park land, 275,552 acres of private land, and 8,079 acres of State Forest land for a total of 906,783 acres. Understanding the past, present, and possible future of the vegetation, riparian communities, wildlife, and other ecosystem components will help identify the potential and limitations of the watersheds involved in this analysis.

This assessment is a blend of current scientific knowledge, information gathered during on-site visits, interviews with local publics familiar with the area, and a review of existing records and documents . New inventories and surveys to fill gaps in existing information will be added to future updates.

This is not a decision document. It will neither resolve issues, nor provide answers to specific policy questions. This document is prepared to provide a foundation for project level analysis and support the line officer in decision making.

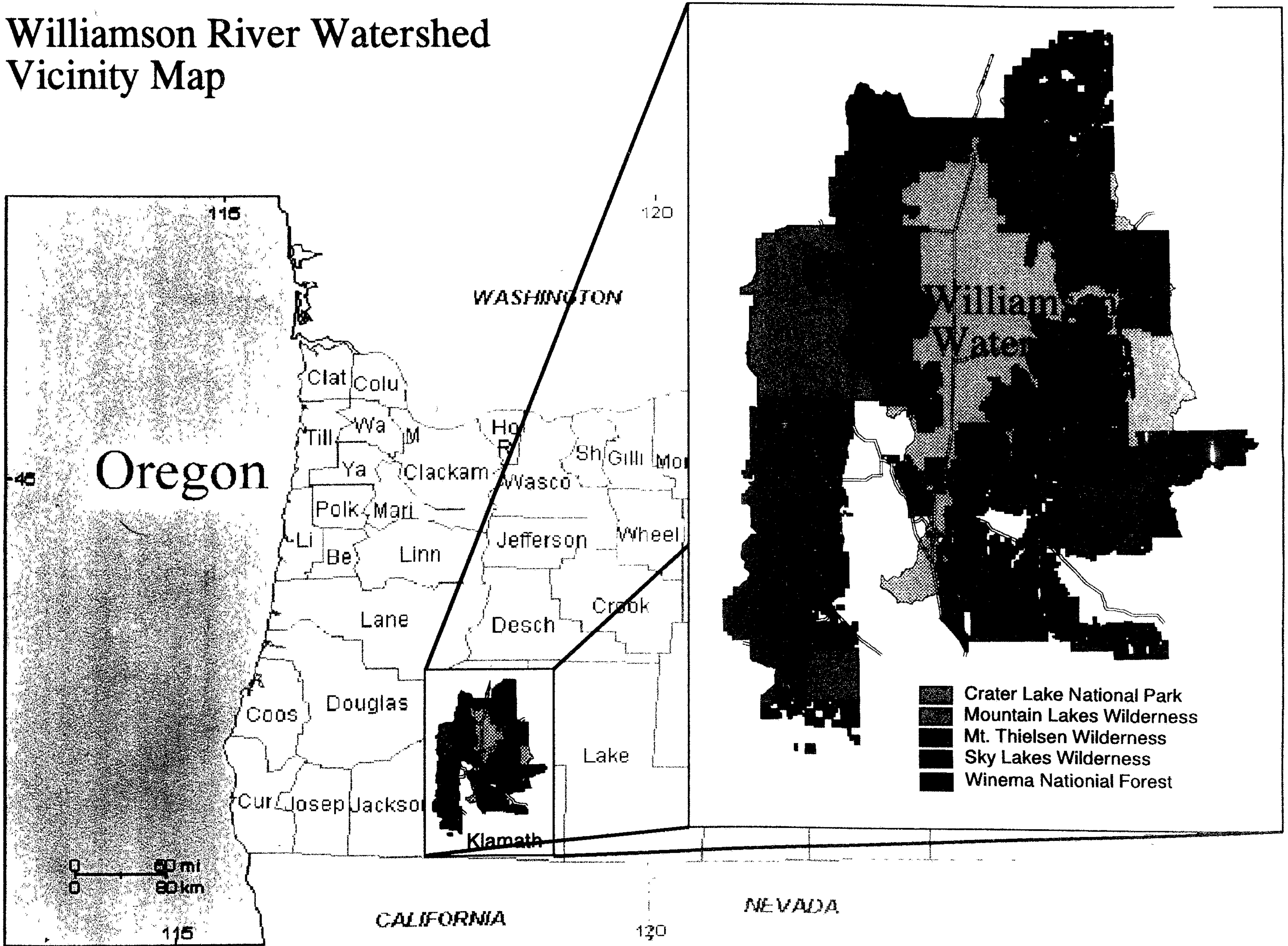
This assessment is a blend of formats used in previous analyses, and the format described in the Ecosystem Analysis at the Watershed Scale, Federal Guide for Watershed Analysis. We have focused on the issues defined by the Chiloquin and Chemult District Rangers, while following the format suggested by the Guide. Issues were identified under each core topic defined in the Guide (a soils section was added), and were addressed in the core questions also found in the Guide.

The original intent of this analysis was to consider everything that drains into the Williamson River as part of the analysis area. However, late in October 1997 it was decided that the Lower Williamson River below Kirk was actually more related to Spring Creek, Larkin Creek, and the Sprague River system. "The analysis area with respect to the aquatic ecosystem is bounded downstream by the hydraulic control of Klamath Marsh, just upstream from the FS 43 road bridge at Kirk. This is due to the differences in the genetic stock of aquatic species above and below this point. In particular, the rainbow trout above Kirk are an older strain than those inhabiting the lower Williamson River and Upper Klamath Lake. Differences in genetics of other fish may also be manifested by the same barriers that existed for trout, but no information is available. Therefore, due to a lack of genetic interbreeding with trout stocks below the Kirk reef, the downstream boundary of the analysis area will be at Kirk reef." Since the logic is relatively sound, the Spring Creek (1801020103B) and Williamson River subwatersheds (1801020103Z and 104Z) will be added to the upcoming North of Sprague watershed analysis.

The maps found in this analysis are all available on the IBM ArcView system. They are kept in the /go/wtrshed directory, and can be accessed by anyone with an IBM profile. They can be useful for project planning, as project boundaries can be clipped to the maps and enlarged.

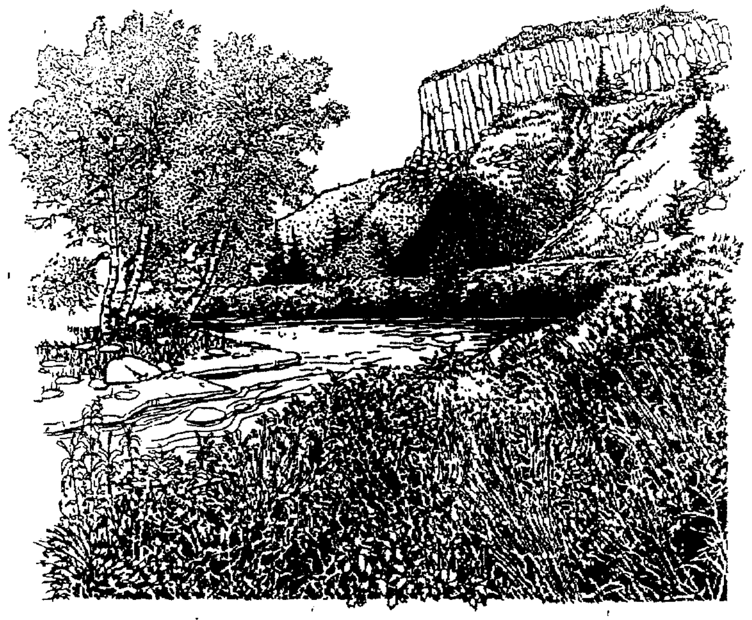
In order for the assessment team to assess the condition, function and processes of the watersheds, two time frames were selected: pre-1875, and current. These time frames were selected because 1875 marks the approximate beginning of the Euro-american influence within the watershed, which changed the conditions and thereby the functions and processes.

Williamson River Watershed Vicinity Map



OVERVIEW

Formative Landscape



The Williamson River Basin is located at the extreme northwestern edge of the Basin and Range Province (Baldwin 1964). It is bounded on the west by the crest of the High Cascades and on the north by the High Lava Plains. Klamath Basin is somewhat unique in a province generally characterized by internal drainage, in that the Klamath River provides external drainage to the ocean. The primary topographic and hydrologic features of the river basin, per se, are largely controlled by a series of northwest trending faults. A combination of basin subsidence and mountain uplift, along with external drainage, has contributed to the formation of large, shallow freshwater lakes and marshes that render the Williamson River Basin distinctive. Throughout this zone, features of faulting, volcanism, and glacial activity are evident, setting the conditions for local hydrologic development.

The western edge of the basin is formed along the crest of a series of irregularly spaced high volcanic peaks that dot the eastern flank of the Cascade Range. All of recent Pliocene and Pleistocene formation, the mountains rise sharply to elevations from 7,000 to over 9,000 feet (Baldwin 1964:69). Prominent on the western horizon are the peaks of Mt. Thielsen (elevation 9,182 ft), Mt. Scott (elevation 8,926 feet) and Crater Peak (elevation 7,265 ft). Notable along the western rim is the caldera of Crater Lake formed by the eruption of Mt. Mazama about 7,700 years ago. Mt. Mazama, thought to have been upwards of 12,500 feet elevation, blew its top and collapsed to form the crater, which subsequently filled with water (Baldwin 1964:75). The explosion removed the upper third of the mountain, and an incandescent cloud of pumice poured down the mountainside. Airborne pumice was carried northeastward by wind that deposited a blanket of pumice as far north as Bend. At Chemult, pumice deposits over 40 feet deep are common. A balance between precipitation and seepage and evaporation has kept the lake near its present level throughout historic times (Baldwin 1964:75).

The western slopes of the basin are generally heavily forested but include a considerable variety of forest types, ranging from the high elevation mountain hemlock zone, through mid-elevation Shasta red fir, to the white fir/ponderosa zone along the lower slopes of the basin (Hopkins 1979). A poorly defined and highly variable white fir-alder/shrub meadow association occurs along creeks. Miscellaneous wetland types occur on glacial outwash fans while lowlands include bluegrass and sedge dominated meadows, tule marshes, and groves of willow, cottonwood and aspen.

Eastern slopes of the Williamson River basin are bounded by a series of low ridges formed along a series of northwest trending faults. In the central basin (as observed in exposures in Swan Lake and

Yonna valleys), Late Miocene to early Pliocene volcanic rocks are overlain by Pliocene lakebeds, portions of which were subsequently buried by a thick layer of basaltic lava as much as 1,000 feet deep (Baldwin 1964:126). Late in the Pliocene and early in the Pleistocene, the area was fractured by a series of northwest trending faults. Volcanic cones such as Sugarpine Mountain (elevation 6,393 feet) in the north of the basin, Yamsay Mountain (elevation 8,196 feet) on the east, and Solomon Butte (elevation 5,763 feet) on the southeast developed along these fault lines. Slickensided scarps are exposed in road cuts along Highway 97 north of Klamath Falls.

In early Pleistocene times the basins of Klamath Marsh and Upper Klamath lake apparently were much larger; however, although more extensive horizontally, they were maintained as shallow lakes and marshes by the continued subsidence of the basin in the face of abundant sedimentation and uplift along the eastern fault scarp (Sherrod, personal communication 1996). In any case, it is apparent that the eruption of Mt. Mazama about 7,700 years ago contributed an enormous amount of sediment to the lake and marsh basins, filled the canyon of the Williamson River as well as many tributary streams, blocked stream outlets, and for a short period of time caused a deep lake to be formed in Klamath Marsh (David Sherrod, personal communication 1996). As evident in the steep profiles of the remnant post-Mazama lake shores on the south and east of Klamath Marsh, marsh water levels lowered to present elevations over time, and the deeper lake may have been short lived.

The eastern slopes, low ridges and isolated cinder cones once were covered by open stands of large, mature ponderosa pine; however, timber harvest between 1910 and 1945 removed much of these virgin stands. Klamath Marsh, always dynamically changing in size in response to changes in local climate and available moisture, hosts abundant expanses of cattail and tule in its shallows (waters generally less than 1 meter deep) and vast floating mats of water lily in somewhat deeper waters (generally between 1 and 3 meters deep) (Guard, 1995). These plants, the water lily in particular, were essential to native Klamath Indian culture. Waters deeper than 3 meters tend to remain open and provide important habitat for fish and waterfowl. Water diversions for irrigation purposes, and drainage of former marsh lands has reduced the extent of the *deep water* marsh so critical for wildlife, as well as the abundance of water lily seeds once central to Klamath Indian subsistence.

Land Management Allocation

Lands included within the Williamson River Basin presently compose a patchwork of different ownerships and managements including federal, state, private, city, and tribal lands. Lands under federal management include those managed by the Winema National Forest (532,316 acres), which accounts for most of the federal lands in the basin (and 59% of the total basin lands), Klamath Forest Wildlife refuge (≈37,906 acres), and Crater Lake National Park (51,574 acres). State lands account for only 8,079 acres and include those managed by Collier State Park and those located within the Sun Pass State Forest. Private lands compose a significant percentage (30%) of the area within the basin with 275,552 acres total, distributed among private logging companies [notably U.S. Timberlands (formerly Weyerhaeuser) and Crown Pacific (formerly Cavenham)], several large ranches, and numerous small residential parcels. The incorporated town of Chiloquin is located in the basin, and the Klamath Tribes recently purchased 40 acres south of Chiloquin and built a casino on the site.

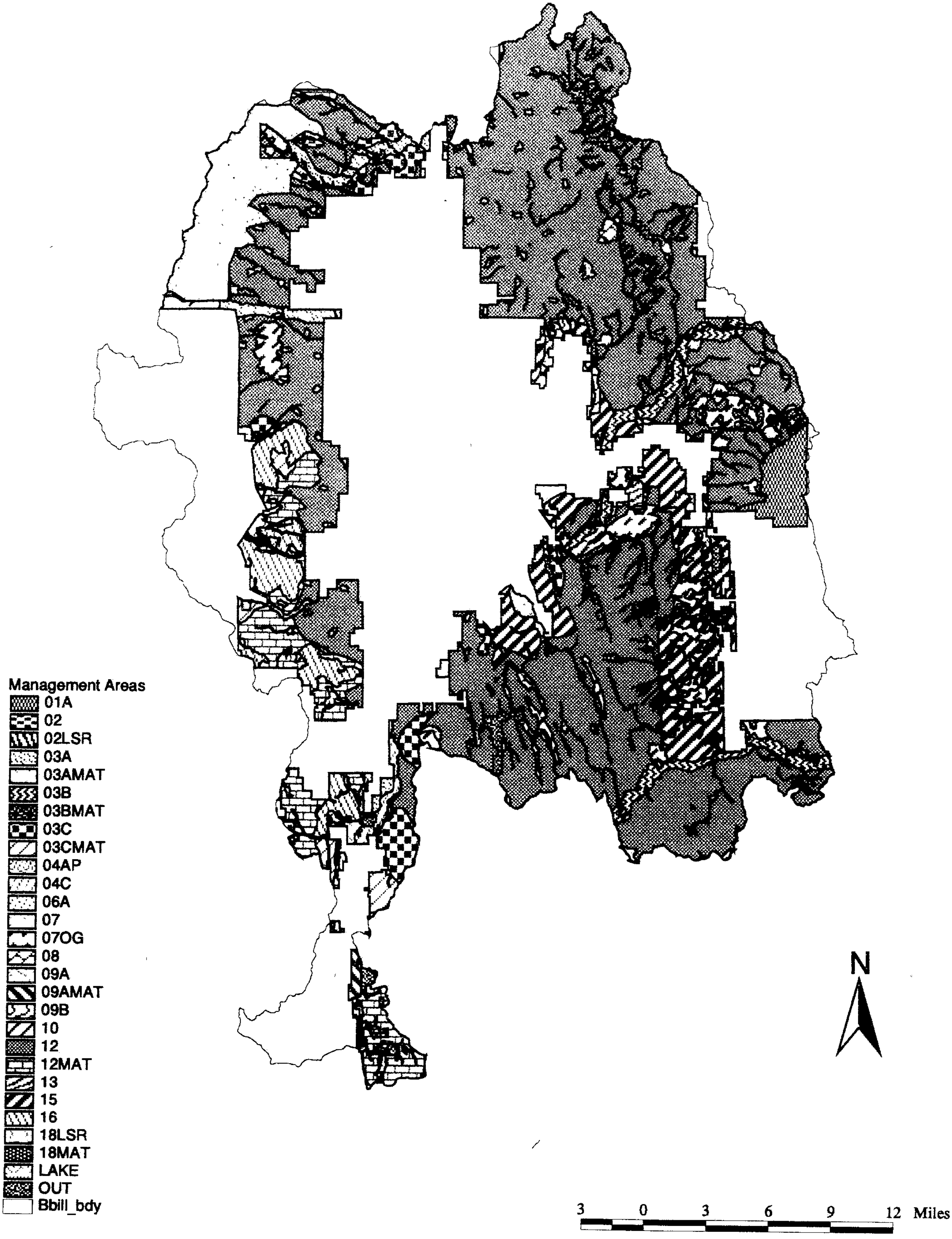
The general breakdown of land ownership is as follows:

FEDERAL (69%)	**623,152 Acres**
National Forest	533,572 acres (59%)
US Fish and Wildlife	37,906 acres (4%)
National Park	51,674 acres (6%)
STATE (<1%)	**8,079 + Acres**
Sun Pass State Forest	8,079 acres
Collier State Park	<100 acres
PRIVATE (30%)	**275,552 Acres**
Commercial Timber	185,899 acres (20%)
Other Private	89,653 acres (10%)

Management practices on these lands differ widely as each developed from different human motivations and became established according to distinct legal mandates. The Winema National Forest has identified 26 different Management Areas within the analysis area (See Management Areas Map). They are:

01A	Yamsay Mountain Semiprimitive Recreation Area
02	Developed Recreation
02LSR	Developed Recreation in Late Successional Reserve
03A	Scenic Management, Foreground Retention
03AMAT	Same as 03A, within Northwest Forest Plan (NWFP) boundary
03B	Scenic Management, Foreground Partial Retention
03BMAT	Same as 03B, within NWFP boundary
03C	Scenic Management, Middleground Partial Retention
03CMAT	Same as 03C, within NWFP boundary
04AP	Unique Management Area, The Pinnacles
04C	Unique Management Area, Williamson River Gorge Scenic Area
06A	Mount Thielsen Wilderness
07	Old-Growth Ecosystems
07OG	Same as 07, added as a result of NWFP decision notice
08	Riparian Areas
09A	Bald Eagle Nest Sites and Recovery Sites
09AMAT	Same as 09A, within NWFP boundary
09B	Bald Eagle Replacement Habitat
10	Big Game Winter Range
12	Timber Production
12MAT	Same as 12, within NWFP boundary
13	Research Natural Areas
15	Upper Williamson
16	Late Successional Reserve (LSR)
18LSR	Riparian, within LSR
18MAT	Riparian, within NWFP boundary

Williamson Watershed Management Areas



For a full description of the management objectives for each area see the Winema National Forest Land and Resource Management Plan (LRMP). The Owl Range map on the next page shows the NWFP boundary

Management History

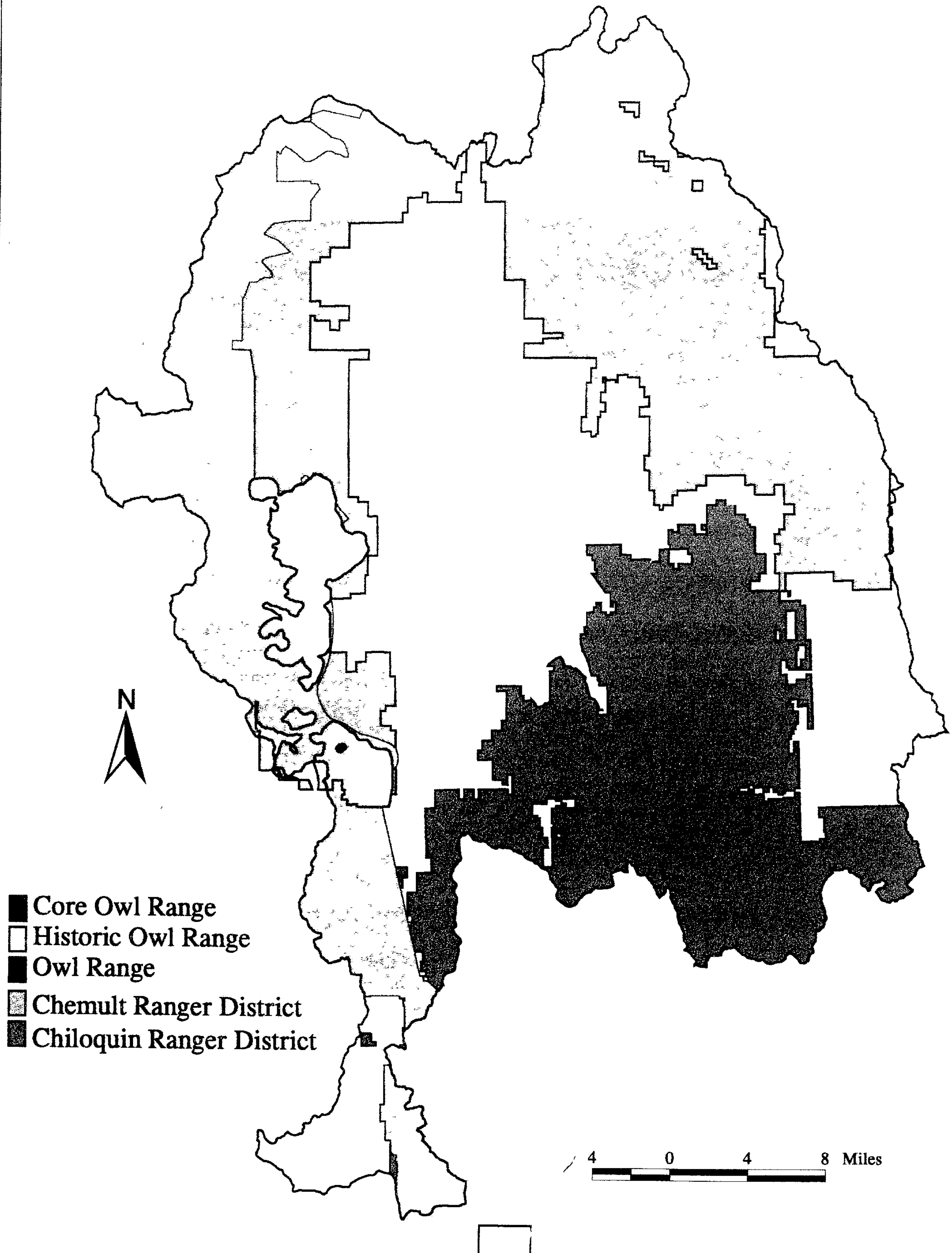
Two different management motivations are needed to understand the history of the Williamson River Basin On the west, the forested mountains of the High Cascades were set aside, excluded from settlement, and reserved for public uses. Primary issues of concern in the 1880's and 1890's were focused on conserving the vast forest resources that were systematically under attack from settlers, sheep herders, and timber companies. Most of the unclaimed forested lands were set aside as part of the Cascade Range Forest Reserve, established in 1893 under the Department of the Interior. Objectives centered on restricting settlement, regulating sheep grazing, suppressing the violent outbreak of uncontrolled wildfires, and preserving timber resources. In 1905, the lands were transferred to the department of Agriculture and placed under management of the newly created Forest Service. Initially, these were included as part of the Crater National Forest, then the Rogue River National Forest, and ultimately becoming part of the Winema National Forest in 1961. The unique geologic area surrounding Crater Lake was set aside as Crater Lake National Park in 1902 "as a pleasure ground for the benefit of the people of the United States" (Greene 1984:99).

Lands within the central and eastern river basin were set aside as the Klamath Indian Reservation under the Klamath Indian Treaty of 1864. The formation of the reservation resulted in the initial set aside of 1,196,872 acres for the exclusive use of Indian peoples. This removed Indians from about 20 million acres so that these could be freed up for non-Indian settlement and agricultural development. At the same time, the reservation was to be for the exclusive use of Indian people until such time as they could make the transition into the larger American society. Members of the Klamath Tribes were granted exclusive rights to hunt, fish, gather and trap within the reserved area, and they were to be protected there from any unauthorized non-Indian use. Similar concerns with unregulated grazing, wildfire suppression, and timber resources were the focus of land management on the Klamath Indian Reservation; however, these occurred somewhat later than on the Cascade Reserve lands.

The allotment policy of the late 1880's was designed to accelerate the transition of hunting and gathering peoples on the reservation to settled farmers. Under the General Allotment (Dawes) act of 1887, about 275,000 acres of tribal reservation lands were allotted to individual Indian families in parcels of from 80 to 160 acres each. These were held in trust for 25 years, after which lands could pass into private Indian ownership and be sold. Upon granting title, many allotments comprising the best agricultural lands were sold to non-Indians. By 1926, about 20,000 acres of the "...good hay land, necessary for winter cattle feed," was in the hands of "some of the most influential and wealthy operators of the region" (Moore 1945:4). The effect was the loss of communal tribal lands and transfer of the best agricultural lands to non-Indian ownership.

The Klamath Termination Act of 1954 terminated federal supervision over the property of the Klamath Indians. Under the terms of this act, the adult members of the tribe were given the option of holding their interests in common under state law or converting them to cash. In 1958 an election was held, and

Owl Range

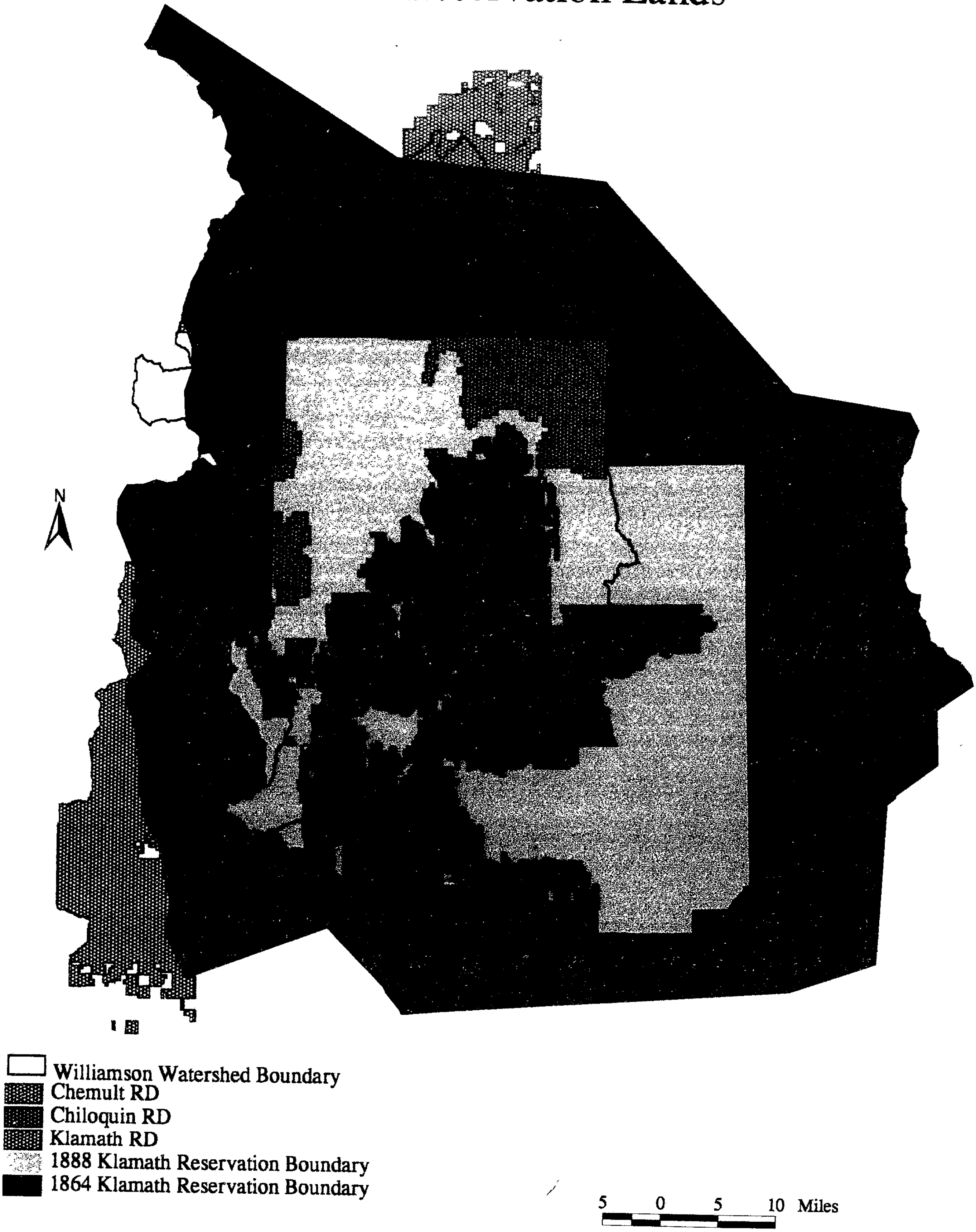

N
Core Owl Range
Historic Owl Range
Owl Range
Chemult Ranger District
Chiloquin Ranger District
4 0 4 8 Miles

77 percent of the tribal members elected to convert their assets to cash A proportionate share of the assets was sold: 91,000 acres were purchased by a private corporation; 15,000 acres were purchased to form Klamath Forest National Wildlife Refuge; and 525,000 acres were purchased to become part of the National Forest System. About 405,000 acres were included in the newly formed Winema National Forest, with the remaining 120,000 acres included under the Fremont National Forest. Between 1959 and 1969, the remaining 144,000 acres of former reservation were administered by the U.S. National Bank of Portland, as trustee for the remaining members. In 1969 the remaining members elected to terminate the trust, and in 1974 the lands became part of the Winema National Forest (see Former Reservation Lands map next page).

The Klamath Tribes were restored as a federally recognized tribe in 1986, but reservation lands were not. With the restoration of the Tribes, focus has turned to defining government-to-government relationship with the Forest Service and to commenting on projects that may affect game herds and fish populations. Treaty rights to hunt, fish, trap, and gather plants were retained on former reservation lands, and this was reaffirmed in 1981 by the Kimball vs. Callahan decision. The Klamath Tribes also are concerned for the protection of cultural heritage sites, for the maintenance of plant collection areas, for unrestricted use of summer camps, and for access to religious sites.

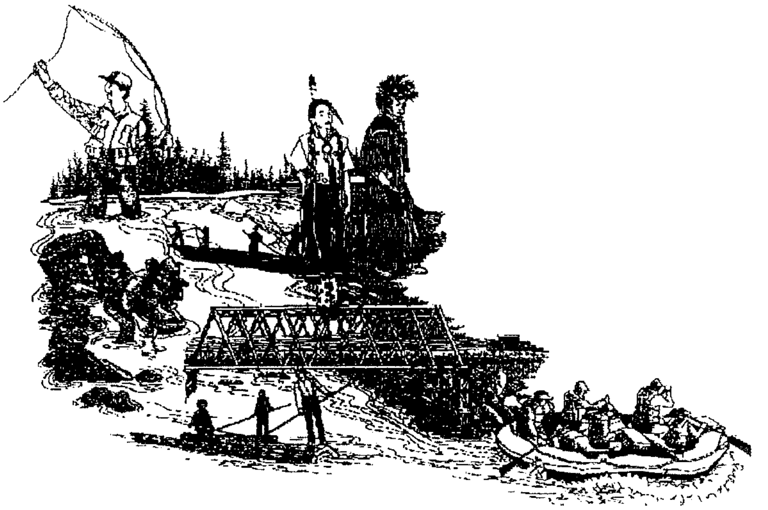
The Winema National Forest has been managed under several different multiple use plans since its conception. Management activities included such items as recreation, grazing, timber harvest, wildlife management, etc. The Winema is currently operating under the Land and Resource Management Plan (LRMP), as amended. Key amendments include the Northwest Forest Plan, INFISH, and the Continuation of Interim Management Direction Establishing riparian, Ecosystem and Wildlife Standards for Timber Sales. It is expected that the LRMP will be amended again with the release of the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The Record of Decision for the LRMP was signed September 19, 1990.

Former Reservation Lands



I HUMAN USES

Current Conditions



Current human uses in the Williamson River watershed center around agriculture, grazing, timber harvest, hunting, fishing, dispersed recreation, and tribal uses. Maintenance of deer herds for hunting is of concern to tribal members as well as other hunters who use the area.

Agriculture and Grazing

Grazing and livestock production has played an important role in changing the function of riparian and aquatic systems within the analysis area. Grazing practices and development of pasture lands, both in and outside the analysis area, have contributed towards lowering water tables. Most of these activities occurred during the first half of this century. Diversions, ditches, and pumping water to either drain wetter areas and/or irrigate drier pastures on private lands, has played a major role in changing the composition of plant species, and the extent of water dependent riparian plant communities.

Many former marshes and wetlands located on private lands were converted to agricultural uses between 1900 and 1940. Wetlands surrounding Klamath Marsh and the lower Williamson River were drained, largely to create hay pastures, and waters were diverted via extensive irrigation networks. The lower reaches of most major streams tributary to the Williamson River are managed as private ranches. Many streams have been modified and diverted from their original outlets into Klamath Marsh. Private ranch lands are used year round for cattle grazing.

Forested uplands under National Forest management, and Klamath Marsh managed by US Fish and Wildlife Service, are used for seasonal grazing, largely by cattle. Previous to the formation of the Forest Reserves in the early 1890's, huge unregulated flocks of sheep grazed the upland meadows in summer. Beginning in 1903, grazing on the Forest Reserves came under a permit system that regulated both numbers of animals and season of use. A similar permit system was initiated on the Klamath Reservation, but effective regulation was more difficult and came later.

Beginning in the 1860's and continuing well into the late 1930's, lands on the Klamath Reservation were subject to unregulated trespass by non-Indian sheep herders and cattle ranchers. In 1918 there were 13,000 Indian-owned cattle on the reservation and about 30,000 head of non-Indian privately owned (Moore 1945:4-5). The lack of winter range on tribal lands made sheep herding difficult for the Indians. Non-Indian owned sheep were first permitted to graze on the reservation in 1922; in 1943, 30 bands of outside sheep totaling 27,371 head were counted (Moore 1945:5). The number of un-permitted livestock, especially in the early years, is difficult to estimate, but judging from the numbers of Indian complaints in the BIA records, it must have been considerable.

Grazing in more recent times (since the 1980's) has been undergoing dramatic changes in both numbers, intensity of grazing, areas excluded from grazing, and management of livestock. Numbers of permitted animals have been progressively reduced on federal lands. Animal use of riparian lands is controlled within the summer season by regulating the time of putting out as well as the duration of use in any given area. With the creation of the Klamath Forest National Wildlife Refuge in 1961, livestock use on 15,000 acres of former reservation and about 22,000 acres of private land acquired in 1989-1990 has been substantially reduced. The trend on federal lands is to reduce grazing, and in some cases, remove livestock altogether. As the Forest Service curtails public land grazing, a heavier emphasis has been placed on active private lands.

The historical effects of grazing throughout the Williamson River Watershed are apparent today Grazing has reduced or eliminated hardwood communities that are associated with live water sources, either developed or natural. Water diversion, to both drain wetlands and irrigate pastures, has contributed to lowering of water tables, changing plant communities, and reducing the extent of riparian plants and natural wetlands.

Timber Production

Timber production has varied in intensity over time, and in various parts of the Williamson River watershed. Commercial timber harvest on National Forest, Klamath Reservation, and on large privately owned timber lands became a primary emphasis after 1909, with the arrival of the Southern Pacific Railroad and the opening of the Klamath basin to outside markets.

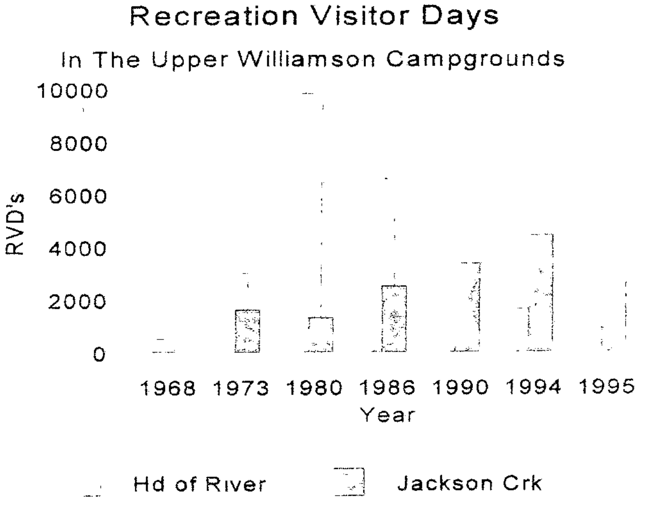
In summary, available records indicate that more than 4.4 billion bf of virgin timber were harvested from the Williamson River watershed between 1918 and 1958. Until 1940, most companies relied on railroad logging methods, either spurring in directly to the harvest areas, or by using truck transport to reload stations along mainline railroads. Presently, more than 702 miles of logging railroad grades have been recorded on the Winema National Forest.

By 1960, most of the virgin timber stands in the watershed had been harvested. Emphasis shifted to harvest of secondary growth on both private and newly created Winema Forest lands, but volumes harvested after the termination of the reservation in 1954 were much lower. The next significant period of harvest started during the late 1970's, and extended through the mid 1980's. Also during this time frame, the Yamsay Tract, owned at that time by Weyerhaeuser Company, was heavily harvested. As timber supplies became tighter during the 1990's, other private landowners in the Williamson River watershed began harvesting timber under their control.

Presently, the trend is toward a reduction of large scale timber harvest on Forest Service lands. The commercial motivation has been replaced with an emphasis using harvest methods to promote forest health, while at the same time protecting vulnerable watersheds.

Recreation

Major recreational uses of the Williamson River watershed are focused on dispersed camping, hunting, fishing, sight seeing, and firewood gathering. Developed recreational sites are located at Crater Lake National Park and Collier State Park. Crater Lake is recognized for its unique geology and spectacular natural beauty. Primary uses of the park are for sight-seeing, picnicking, and winter cross-country skiing. Collier State Park provides a day use picnic area, but is primarily known for its historic logging museum. The emphasis on National Forest lands, as well as within the Klamath Forest National Wildlife Refuge, is on dispersed camping, hunting, and fishing. Firewood gathering on National Forest lands has also received emphasis in recent years.



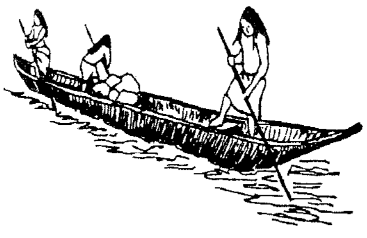
There are eight campgrounds on Forest Service administered lands: Digit Point, Corral Spring, Chemult Sno Park, Jackson Creek and Scott Creek on the Chemult District; and Oux Kanee, Williamson River and Head of the River on the Chiloquin District. Recreation use at Head of the River campground was reduced in 1984 by limiting the number of camping units and restricting vehicle movement. Pole fencing was installed to prevent further resource damage. Recreation user days information is shown at right.

The major types of dispersed recreation are associated with big game hunting, fishing, firewood gathering, and waterfowl hunting at Klamath Marsh and along the Williamson River. Other minor activities include sightseeing, horseback riding, and birdwatching. Recreation on private lands, conducted primarily for profit, include fee fishing, hunting for waterfowl, and bed/breakfast operations. These private land operations are just starting, and could become a bigger factor in the recreational picture as traditional income sources (livestock grazing, timber production) become less viable in the next 20 to 50 years. The Klamath Tribes recently purchased 40 acres of private lands, and have built a casino just north of where the Williamson River crosses Hwy 97.

The trend suggests that recreational uses will continue to increase in the future. More people are expected to use federal lands for dispersed recreation. We may also see future demands for more developed recreational sites. Economically motivated ventures on private lands are also likely to increase. Effects of this may be seen as competing interests, as more people visit the forests seeking undeveloped natural settings, along with those who seek developed recreational experiences and those who seek to profit from recreational users. Effects of increased usage are already apparent in the increased dumping of trash from locals and visitors, disturbance of game and wildlife, and an increase in the number of human caused fires.

Firewood cutting in the watershed was not very significant until the mid 1980's when sources closer to Klamath Falls and Chiloquin were exhausted. From the late 1980's and into the early 1990's, firewood gathering in the area increased. A large area between the Williamson River Road and the Skellock Draw Road and east of Buckhorn Springs Road was opened for free-use. Firewood cutters have traversed most of the meadows for pockets of dead lodgepole pine. Prior to Forest Service administration, most firewood gathered tended to be ponderosa pine. This practice was discontinued in the early 1980's, after concerns were raised about the loss of this resource for cavity nesters and roosting perches for raptors, especially eagles.

Tribal Uses



The Klamath Tribes retain treaty rights to hunt, fish, trap, and gather plants on former reservation lands. Hunting and fishing is conducted year round under regulation by the Klamath Tribes; deer and elk are the primary capture species. Fishing was extremely important in native Klamath subsistence, but changes in species abundance, among other reasons, has diminished the emphasis on fishing. Tribal members also collect wocus (water lily) seeds in Klamath Marsh and have strong cultural values associated with heritage sites located around the marsh.

Some tribal members gather native medicinal and food plants, but no plants have been identified that are uniquely gathered for religious ceremonial purposes. Plants gathered today for food, medicine or materials include epos, camas, wocus, serviceberry, currant, wild rose, cattails, and tules. Among these, the collection of wocus (water lily) seeds is important as a means to celebrate and renew cultural traditions. Wocus was once central to Klamath Indian subsistence; its collection today reaffirms cultural identity by maintaining important values and traditions.

Lands included within the Williamson River watershed include several unique cultural areas, especially those relating to spiritual uses on Yamsay Mountain. Seasonal hunting camps, administered under special use permit to the Tribes, are located at Rocky Ford. Similar hunting camps are located on Jackson Creek and elsewhere in the watershed, although apart from the camp at Jackson Creek, these are not under special use permit at present. In addition to serving as the basis for exercising hunting and fishing treaty rights; these camps are places to socialize, make jerky, tell stories, and renew cultural traditions. Camps on Rocky Ford and Jackson Creek also are important relative to certain traditional religious uses of nearby Yamsay Mountain. The top of Yamsay Mountain and the camps at Rocky Ford and Jackson Creek are considered eligible to the National Register of Historic Places, due to the traditional cultural values and uses associated with these areas.

Reference Conditions

Three major events have shaped the human history of the Williamson river watershed: the opening of Oregon Territory to settlement in 1850, formation of the Klamath Reservation in 1864, and the formation of the Forest Reserves in 1893. All; however, can be traced to the 1840's period of American western expansionism and the exploration and settlement of the Oregon Territories.

The early period, between 1825 and 1850, was a period of exploration. The earliest explorers were associated with the Hudson's Bay Company, searching for new streams to trap beaver and other fur bearing animals. The discovery of gold in California in 1848 prompted the establishment of the Oregon Territory in the same year, and quickly gave rise to the period of western emigration. The Oregon Donation Land Act in 1850, whereby each adult United States citizen could get 320 acres of free land in Oregon Territory, prompted rapid Euro-American settlement of Oregon between 1850 and 1890. This period saw rapid settlement of bottomlands suitable for agriculture, but unregulated grazing of nearby forests, usurpation of timber through fraudulent land claims under the Timber and Stone Act, and the increase in wildfires from increased human uses gave rise to a conservation movement in the 1880's that led to the formation of the Forest Reserves in 1893.

Forested, mountainous lands on the western edge of the watershed were included in the Cascade Range Forest Reserve in 1893. Primary issues of concern at the time were to regulate sheep grazing, suppress the violent outbreak of uncontrolled wildfires, and preserve timber resources. In 1905 these lands were transferred from the Department of Interior to the Department of Agriculture, and were placed under management of the newly created Forest Service. Lands on the west side of the watershed now included within the Winema National Forest were initially mainly located within the Crater National Forest, which became the Rogue River National Forest in 1932 (Brown n.d.).

The remainder of the watershed came under the Klamath Indian Treaty of 1864. The formation of the reservation, in response to Euro-American expansionism, resulted in the initial set aside of 1,196,872 acres (about 1.5 million less than negotiated under the treaty) for the exclusive use of Indian peoples The motivation was to remove Indians from about 20 million acres so that these could be freed up for non-Indian settlement and agricultural development. At the same time, the reservation was to be for the exclusive use of Indian people until such time as they could make the transition into the larger American society. Similar concerns with unregulated grazing, wildfire suppression, and timber resources were the focus of land management on the reservation; however, these occurred somewhat later than on the Cascade Reserve lands.

The problem with unregulated sheep grazing in the western mountains was most severe in the years following initial settlement, and into the early years after formation of the forest reserves, between about 1850 and 1900. Several hundred thousand sheep were annually pastured in the High Cascades in the 1890's (Steel 1896, in Williams 341-2). By 1903; however, a permit system was initiated.

At the same time, huge tracts of virgin timber were annually destroyed by wildfire, many thought to be set by sheepmen to increase their forage base. “These fires rage to such an extent, that from early June to the coming of rain in September, the entire country for a thousand miles along the coast is enveloped in a thick pall of smoke” (Steel 1896, in Williams 341).

Pre-contact Period

The edges of Williamson River and Klamath Marsh were important parts of Klamath Indian life before the advent of EuroAmerican settlement. Winter villages were located along the edges of the marsh and all along the lower reaches of the Williamson River; summer villages were located along the upper Williamson. The marsh provided abundant plant foods, waterfowl, and year-round fishing. Water lily seeds (wocus) were an important staple, as they could be stored over the winter. Coville (1902:728) estimated that in 1902 Klamath Marsh contained “about 10,000 acres of a solid growth of wokus”. The technological, linguistic, and cultural elaboration associated with wocus use, and the persistence of Klamath Marsh as a shallow water body over several thousand years, suggests this plant has long been available for use by the Klamath Indians.

Early exploration - 1825-1850

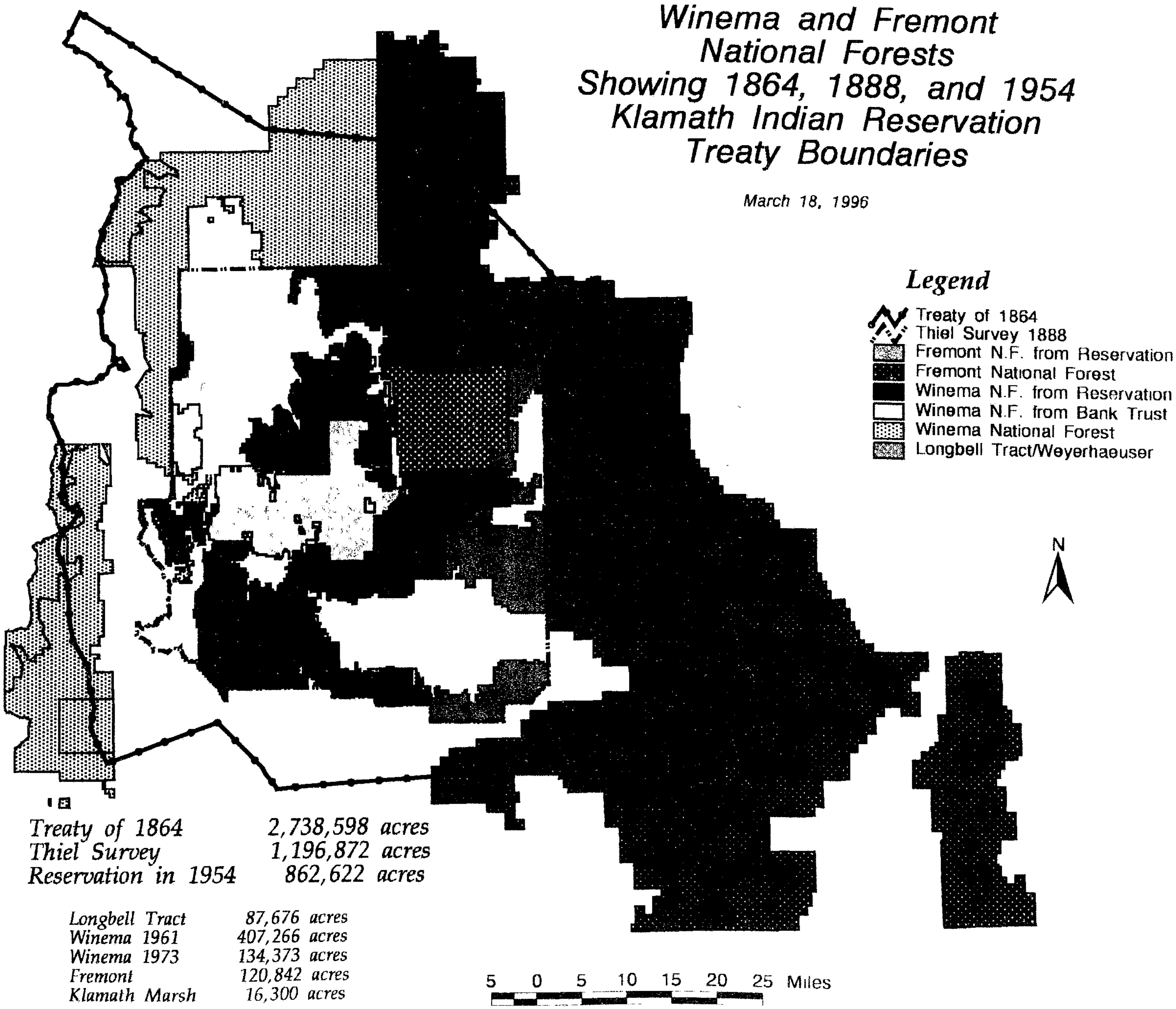
Several early historic views of portions of the watershed are available in the form of early explorers' accounts. Following Indian trails into the Klamath Basin, the earliest historic accounts of the area are from fur trappers' journals. Peter Skene Ogden traveled along the east side of Klamath Marsh between November 29 and December 2, 1826. His account speaks eloquently of hunger, cold, scarce game, and virtually none of the beaver for which they were searching (Davies 1961). Ogden visited an Indian village, apparently built on piles in the marsh, and approachable only by canoe. Although friendly to Ogden's party, the Indians expressed regret that a communication had been opened to their lands (November 29, 1826).

John C. Fremont followed the same Indian trail used by Ogden between December 10 and 15, 1843. Fremont camped on the west side of the marsh, at present Military Crossing, and then traveled up Skellock Draw and crossed over the lower slopes of Yamsi Mountain. In contrast to Odgen's bleak view of Klamath Marsh in 1826, Fremont (1845) found it "...a picturesque and beautiful spot; and under the hand of cultivation, might become a little paradise" (December 11, 1843). He did not; however, present the Klamath Indians as friendly but highlighted the importance of the area as "... the line of inland communication with California, and near to Indians noted for treachery, it will naturally in the progress of settlement of Oregon, become a point for military occupation and settlement" (December 11, 1843).

Ten years after Fremont's journey, Leuts. R.S. Williamson and Henry L. Abbot explored the Klamath Basin in search of a railroad route linking the Sacramento Valley and the Columbia River (Abbot 1857). At their camp on the east side of Klamath Marsh near Military Crossing, on August 21, 1855, Abbot provides a more detailed picture of Klamath Marsh as "a strip of half-submerged land, about twelve miles long and seven miles broad....covered by clumps of tule and other aquatic plants separated by small sheets of water. Thousands of ducks, plover, and other water birds made it their home" (Abbot 1857). By this time, the Klamath fled at the approach of the exploring party, no longer trusting to any friendliness. It was the time of the wocus harvest, and Williamson noted the "large quantities of food, mostly consisting of the seeds of water plants and dried fish...." (Abbot 1957).

Reservation Period 1864-1961

By the 1860s, traditional life ways of the indigenous peoples was already much disrupted and the Klamath, Modoc , and Yahooskin Paiute agreed to sign a treaty ceding most of their traditional lands, in exchange for an area to be set aside for their exclusive use. The three groups combined ceded about 15 million acres of their native territories with the treaty of 1864. In the original treaty language, a reservation was to be formed extending between prominent, named peaks. The "peak-to-peak" reservation included about 2,738,598 acres (as calculated by GIS); however, several factors were underway even as the treaty was being signed, that reduced the Reservation to less than half this size. By the time the land surveys were conducted between 1871 and 1900, settlers were already occupying lands in the basin; and it was felt by some in the Indian Agency that the original peak to peak reservation was too large. The Thiel survey of 1888, which eventually came to demarcate the outside boundary of the Reservation, consisted of 1,196,872 acres. Enclosed within this; however, is a 90,000 acre block of land that came to be known as the Yamsi (or Long-Bell) Tract. The map on the next page shows the current National Forest, and current and former Reservation boundaries.


Winema and Fremont
National Forests
Showing 1864, 1888, and 1954
Klamath Indian Reservation
Treaty Boundaries
March 18, 1996
Legend
Treaty of 1864
Thiel Survey 1888
Fremont N.F. from Reservation
Fremont National Forest
Winema N.F. from Reservation
Winema N.F. from Bank Trust
Winema National Forest
Longbell Tract/Weyerhaeuser
N
Treaty of 1864 2,738,598 acres
Thiel Survey 1,196,872 acres
Reservation in 1954 862,622 acres
Longbell Tract 87,676 acres
Winema 1961 407,266 acres
Winema 1973 134,373 acres
Fremont 120,842 acres
Klamath Marsh 16,300 acres
5 0 5 10 15 20 25 Miles

In 1864, the same year the treaty was signed, a group of entrepreneurs organized a company and built the Oregon Central Military Wagon Road through the center of the reservation. Although never used by the military (nor by anyone else for that matter), the road builders were granted every other section of land along its route No one seems to have noticed that the road grants traversed the center of the Klamath reservation until almost 30 years later. The land grants were upheld by a 1906 ruling, and to resolve the problem, a block of land encompassing 90,000 acres in the center of the reservation was exchanged for the 110,000 acres scattered along the military road. The Klamath were not compensated for this land until 1938. This block, known as the Yamsi Tract or Long-Bell tract, was recently sold by Weyerhaeuser Lumber Company to U.S. Timberlands. It is managed for its timber values.

1887: The Allotment Policy

The General Allotment (or Dawes) Act of 1887 was intended to individualize Indians by giving them citizenship and assigning them private tracts (160 acres), to be held in trust by the United States for at least 25 years. The Klamath Reservation was considered best suited to stock raising, and the Klamath Marsh was one of the best areas for putting up hay and raising stock.

Individual family allotments were located in bottom lands along streams in the vicinity of the pre-reservation villages. Klamath Marsh was the most densely populated area, with winter villages located along its south and east edges (Spier 1930).

The allotment policy; however, did not provide sufficient lands to sustain families as farmers or stockmen, and the leasing of individual allotments to non-Indians became common practice. By 1903, payments from leases comprised 30% of total estimated personal income (Stern 1966:143). However, the leasing policy made regulation of stock difficult to impossible, especially on adjacent communal tribal lands. It is likely that unregulated stock initiated many watershed problems we see today.

Leasing was soon replaced by a movement to sell the allotted lands. The original 160 acres per family was minimal for self sufficiency, and so the leasing, but when divided among numerous heirs, the tracts often became "dead allotments" which did not produce anything (Stern 1966:144). This encouraged the rapid transfer to patents in fee simple, and resulted in land sales to non-Indians. By 1924 practically all fee patents had been sold. Of the 1,624 allotments issued, totaling 247,515 acres, 1,130 allotments amounting to 133,000 acres remained in August 1954. By October 1957, 630 tracts remained, totaling 73,681 acres (Stern 1966:145). However, the impetus toward self- sufficiency based on farming and stock raising had been supplanted much earlier with the opening of the reservation to commercial timber harvest after 1910.

Commercial Timber Harvest

When the Southern Pacific Railroad reached Klamath Falls in 1909 and moved north to Kirk in 1911, the reservation timber was opened to commercial markets (Tonsfeldt 1987). Cutting on allotted lands began in 1911. The first tribal timber was sold in 1913. Superintendent Edson Watson proposed the exploitation of tribal timber, arguing that it would provide work for the Indians. He recommended that the reservation timber be cut on a sustained yield basis, in fifty to one hundred year rotations. He advocated large sales of stumpage, as involving lower administration costs, and considered small concerns unreliable (Annual Narrative Report 1914:8, 11-13; cited in Stern 1966:152).

The former Klamath Reservation portion of the Williamson River watershed includes portions of 33 timber management units, at least 28 of which were harvested as individual sales in the reservation era between 1918 and 1958. During this period, 2.7 billion bf of timber were harvested from reservation lands

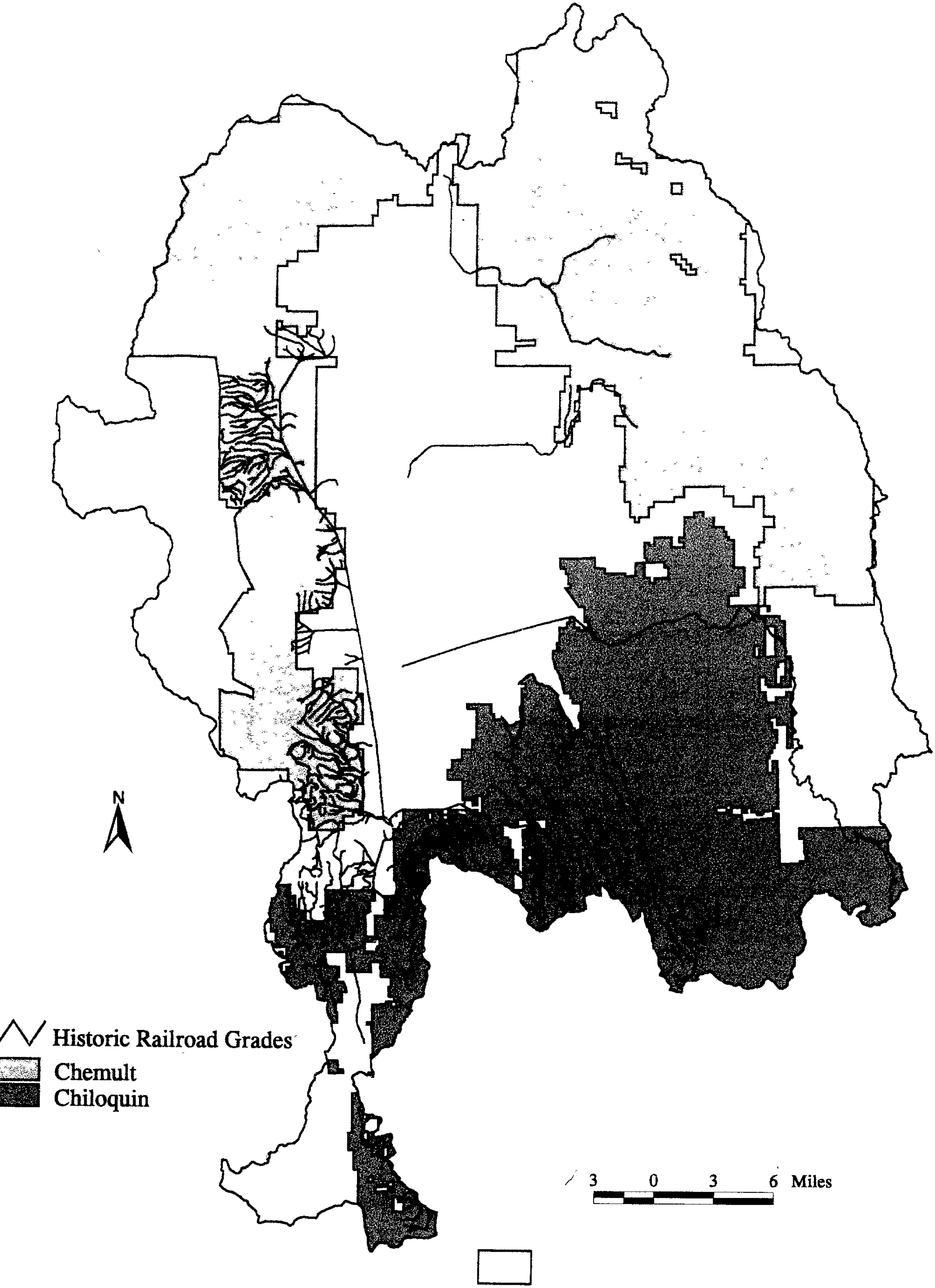
In the early years, from 1918-1935, railroad logging methods were used exclusively to harvest timber. Railroads were spurred directly into the harvest areas. After 1935, trucks were employed to haul logs to reload stations along mainline railroad lines were the logs were loaded on the railroad for transport to the mills in Chiloquin, Sprague River, and Klamath Falls. More than 702 miles of railroad grade have been recorded on Winema Forest lands in the watershed (see Historic Railroad Logging Grades map next page). After 1940, most logging companies used trucks to haul logs directly from the woods to the mills; the result of which was an extensive system of logging roads.

A summary of commercial timber harvest volumes between 1918 and 1958, by land ownership and type of logging method is shown below.

Table . Commercial Timber Harvest Summary, 1918-1958.

Compartment	Begin	End	Volume	Tech	RR Mi	Admin
Allotments	1916	1921				BIA
Fort Creek	1916	1918				BIA
Kirk Mill	1916	1928	18,045,380	RRR		BIA
Spring Creek	1917	1926	70,371,370	RRR	13.2	BIA
David Allotment	1918	1918				BIA
Middle Mt. Scott	1918	1929	316,879,370	RRR	99.6	BIA
S. Mt. Scott	1918	1929	208,245,970	RRR	59.8	BIA
N. Mt. Scott	1919	1927	138,876,580	RRT		BIA
Agency Unit	1920	1924	20,374,100			BIA
Bear Creek	1920	1937	300,000,000	RRT	168.5	CNF
Sand Creek	1920	1920				BIA
Solomon Butte	1921	1928	123,317,820	RRR	83.4	BIA
Calimus Marsh	1922	1937	375,225,220	RRR	184.7	BIA
Big Spring	1924	1925	5,665,490			BIA
Weyerhaeuser	1924	1924	100,000,000	TRE		PRI
Cr. Crk. Sugar P.	1926	1947				BIA
Yamsay Tract	1929	1948	1,400,000,000	TRE	41.7	PRI
Agency Butte	1937	1939	6,899,520			BIA
North Marsh	1937	1946	185,485,010	TRE	20.1	BIA
Sykan	1938	1946	433,161,000	TRE	6.54	BIA
Crooked Creek	1939	1942	24,996,700			BIA
Military Crossing	1943	1944	12,085,040	TRE		BIA
Skellock Draw	1945	1946	23,598,320	TRE		BIA
L Yamsay No. IA	1946	1946	11,783,760			BIA
Shevlin Hixon	1947	1950	375,000,000	TRE	24.6	PRI
Wild Horse No I	1948	1952	88,000,000	TRU		BIA

Historic Railroad Logging Grades



L. Yamsay No. I	1949	1953	32,000,000			BIA
Wild Horse No 2A	1952	1954	33,069,010	TRU		BIA
L Applegate Bldn	1953	1953	132,610	TRU		TST
N. Calimis Fir	1953	1953	704,750	TRU		TST
Up. Wm. River	1955	1956	8,642,000	TRU		TST
Buckhorn Springs	1956	1962	34,085,260	TRU		TST
Wild Horse	1956	1962	58,976,240	TRU		TST
Wild Horse IIB	1957	1958	10,409,550	TRU		TST
Wild Horse IIC	1957	1958	11,165,440	TRU		TST
Wild Horse IIIA	1957	1958	12,510,270	TRU		TST

Administration: BIA = Bureau of Indian Affairs, CNF = Crater National Forest, TST = US Bank Trust, PRI = Private.
Technology used to harvest: RRR = Rail-to-rail, RRT: Both rail-to-rail and truck to rail reload, TRE = Truck to rail reload, TRU = Truck to Mill.

The waterways were also used to transport logs in the early days. The remnant of an old splash dam is located on the Williamson River near Williamson River campground. The structure was built in 1917 by a local Oregon logger named Alfred Knapp to float his logs down the river to the mills on Klamath Lake. He came into conflict with recreational fishermen from California who objected to the effects his log drives were having on the native fishing stream. Although Knapp eventually won the lawsuit filed by the fishermen, he went bankrupt in the process. Historically, this site represents a unique example of early management conflicts between commercial timber interests and recreational enthusiasts. It also preserves some severe impacts to the watershed from when the cannel was straightened and deepened by the release of logs from the dam.

Private lands also were heavily harvested during this period. Between 1929 and 1948, 1,400 mmbf were harvested from the Yamsay Tract. Logs were hauled over Lamm's mainline railroad across Klamath Marsh. Lamm's Railroad is a significant historic site, considered eligible to the National Register of Historic Places. In 1924, on the north edge of the watershed, 100 mmbf was harvested by Weyerhaeuser from their privately held lands.

Commercial timber harvest on Forest Service lands began in 1905. In fact, the first timber sale offered under Forest Service administration was located on the Crater National Forest, just south of the Williamson River watershed. In the watershed proper, The Bear Creek sale, on the former Crater National Forest, cut 300 mmbf of virgin timber between 1920 and 1937. Railroad methods were used to harvest the timber, and this is one of the most heavily graded sales recorded in Oregon, with more than 168 miles of grade recorded (Tonsfeldt 1995).

Synthesis and Interpretation

Two different management motivations are needed to understand the history of the Williamson River Basin. Lands on the west, in the mountains of the High Cascades, relate to formation of the Forest Reserves and the formation of the Forest Service. Initially, these lands were managed to control grazing, suppress wildfires, and preserve vast timber resources. Commercial timber harvest of these lands was an objective from the start, but timber was perceived as a renewable commodity and managed as such. This set the stage for subsequent Forest Service emphasis on timber management. Recreational uses of Forest Service lands from the start also focused on dispersed uses, primarily hunting, camping and fishing. National and state parks on the other hand, developed primarily in response to recreational objectives. Recreational uses of Forest Service lands are increasing; however, while timber production is declining.

Differences in direct land effects from unregulated uses, and impacts on watersheds, in these early days are very similar on the forest reserves and Indian reservation lands. In both cases the emphasis was on regulating non-Indian grazing, controlling wildfires, and exploiting timber resources. They likely differ primarily in terms of timing, duration, and intensity of effects. With the termination of the Klamath Reservation between 1954-1961, many Klamath Indian life ways were disrupted. Traditional patterns of hunting, fishing, plant gathering, camping, and wood cutting were for a time disrupted, that is until treaty rights to hunt, fish, trap, and gather were reaffirmed by the Kimbol vs. Callahan court rulings (1974), the Consent Decree, the Simmons Opinion (1982), and the title Opinion letter of April 12, 1979.

Changes in human uses in the watershed primarily relate to the transfer of lands from Klamath Indian Reservation, under BIA administration, to public lands under Forest Service management. Reservation lands were set aside for exclusive Indian use. The terms of the 1864 Treaty relegated the Klamath Tribes from a state of sovereign independence to a status under the government of the United States, and more directly, under the supervision of an Agent. A program of extensive change was initiated, one designed to make tribal members into farmers and ranchers by American standards. It is probable "..that both parties to the treaty thought the Indians would be able to maintain self-sufficiency by the end of twenty years" (Stern 1966:42).

The Klamath Reservation was considered best suited to stock raising, and the Klamath Marsh was one of the best areas for putting up hay and raising stock. Families who maintained wocus (water lily seed) gathering camps along the marsh were allotted lands here (Stern 1966). Hence, the continuity of traditional culture was maintained into the historic reservation era through the maintenance of family allotments at the marsh. The leasing policy; however, made regulation of stock difficult to impossible, especially on adjacent communal tribal lands. It is likely that unregulated stock initiated many watershed problems we see today.

The allotment policy failed to make tribal members self-sufficient based on farming and stock raising. After 1910, tribal revenues were generated by opening the reservation to commercial timber harvest. Large volumes of timber were cut from the reservation, changing the shape and composition of the original pine forest. With the termination of the reservation after 1954, lands came under management of the Winema National Forest, U.S. Fish and Wildlife Service, and a private logging company. This history of land transfer and management is central to the numerous issues facing both federal land managers and the Klamath Tribes.

Primary effects from recreational activities are the increased off-road use on public lands. As more use occurs, non-system roads in riparian areas may become channelized. This will result in further degradation of riparian communities, as new downcut areas will cause changes in plant species composition and reduce surface water retention capacity in the areas affected. Recreational users may also damage sensitive heritage resources.

As stated above, the changing of ownership from the Klamath Tribes to the Forest Service has played an important role in increasing the level of activity by both tribal members and the general public, and the influence of these activities on the resources of the watershed. The increased access to this area was primarily due to the increase in road and railroad systems that were developed for timber harvesting. These roads by themselves have affected mesic riparian communities and water storage. The road system plays an important part in increasing the number of user-created roads in riparian areas for general recreating, hunting, and firewood gathering. The effects of existing roads, combined with these added user roads, are cumulative on wildlife disturbance. This makes recruitment into existing populations of both game and non-game difficult, and further degrades riparian systems that are key to the general health of the watershed, precluding these areas from being able to store groundwater on a long term basis.

Increased recreational use by local and outside visitors, combined with tribal subsistence hunting and camping, has led to increased trash dumping, increased disturbance of game animals and other wildlife, and increases in the numbers of human caused fires.

The results of long-term fire suppression, combined with recreation and subsistence use, has set the stage for potential large scale man caused fire conflagrations that may affect productivity and health of the watershed.

The development of agricultural lands, both in and outside of the analysis area, has exacerbated the trend of decreasing water retention, through ditching, pumping water, and livestock grazing. It has generally changed some of the mesic riparian communities to a more xeric riparian or upland community.

Recommendations

- → Work with Klamath Marsh Wildlife Refuge managers to cooperatively plan prescribed burns in and along the edges of Klamath Marsh to increase wildlife habitat and reduce the risk of adverse wildfire escape onto nearby forest lands.
- → Work with Oregon Department of Fish and Wildlife (ODFW) and Klamath Tribes to educate the public on the frailties of the ecosystem and the affects off-road vehicle use on riparian areas, wildlife, and watersheds, and how to avoid making unnecessary negative impacts. This could be accomplished with flyers attached to hunting licenses, wood cutting permits, mushroom permits, etc..
- → Increase the level of law enforcement, as well as the number of game wardens.
- → Work with Klamath Tribes, hunters and recreationists to ensure that garbage is removed from dispersed campsites and Indian Camps.
- → Continue to work with and educate private landowners and livestock grazers on the effects to the ecosystem of drainage ditches/diversions, and cattle grazing in sensitive riparian areas.

II EROSION PROCESSES

Issues

The team decided that erosion is probably not a major issue, but that the following factors should be mentioned as the major contributors to erosion in the watershed:

1. Road Systems
2. Downcutting channels
3. Wind erosion following wildfires
4. Compaction

Characterization

The Williamson River watershed is dominated by an extensive marsh and grassland, fed by several distinct topographic and hydrologic environments. South of the marsh, the intermittent drainages of Hog Creek, Yoss Creek and Skellock Draw supply springtime surface flows and groundwater storage for recharge of the marsh water table. To the east, Yamsay Mountain and its high elevation snow pack feed the upper Williamson River, directly or indirectly, with perennial flows from Jackson, Irving, Modoc, Sheep, and Deep creeks. Groundwater recharge from this area feeds several major springs, including Wickiup Spring and Head of the River, supplying cold water to the Williamson River. North of the Marsh, a gently sloping plateau delivers spring flows and groundwater recharge through the intermittent Jack Creek drainage, and to a lesser extent Mosquito and God Creek. To the west, the high Cascades snow pack of the Mt. Thielsen Wilderness area and Crater Lake National Park deliver surface flows through the Miller, Sink, Cottonwood, Pothole, Scott, and Sand creek drainages to the marsh and grasslands, recharging the water table. Big Springs supplies perennial flows to the northwestern portion of the marsh in all but the worst drought conditions. The source of this spring is likely groundwater recharged from the Cascades.

From the central marsh and grasslands the Williamson River flows south through a narrow, deeply incised canyon, joins with the Sprague River at the town of Chiloquin, and flows into Upper Klamath Lake.

The Williamson River basin is made up of gently sloping volcanic topography. The vast majority of slopes (80 to 90 percent) are less than 20%, with much of these lands having slopes less than 5%. The steeper slopes are associated with Yamsay Mountain, Mt. Thielsen Wilderness, Crater Lake National Park and the canyons formed by the major streams draining these highlands. Even here the volcanic landforms rarely offer side slopes greater than 30 to 40 percent.

The gentle slopes, porous nature of the soils, low and moderate intensity precipitation events, the dominance of snow, and the extended spring melt period combine to limit the erosive power of water. The dominant erosion process in the Williamson River watershed is stream bank erosion. Specifically, isolated case erosion from road concentrated storm runoff and snowmelt add to the total sediment production. Every stream in the watershed has examples of destabilized banks, both natural and man caused, contributing sediment to the stream channel. Destabilized banks are a naturally occurring phenomenon that has been accelerated by human manipulation of the environment. All streams in the watershed have been affected by human activities to some extent. The streams or stream segments on the gentler topography have all been subjected to the effects of roads and grazing activities for 70 to 100 years. These streams are estimated to have bank erosion rates significantly above base rates. The streams located in well defined canyons like Jackson, Deep, Miller, Scott and Sand Creeks, etc., have generally been protected from the direct effects of the above activities by topography less favorable to development; therefore, erosion rates are at base levels.

Current Conditions

Three to five miles of road per square mile of land area crisscross the watershed, except for the Mt. Thielsen Wilderness, Crater Lake National Park, Yamsay Mountain, and the Klamath Marsh. Erosion processes associated with roads can include: concentration of storm runoff in road ditches and on the road surface, interception and concentration of groundwater in road ditches, and constriction of stream channels by road fills and culverts.

The stream systems that drain Yamsay Mountain and Booth Ridge to the east of the Williamson River, as well as the high country of Mt. Thielsen Wilderness and Crater Lake, are largely confined in narrow, incised valleys and canyons. The streams in this topography are generally classified as Rosgen type "A" and "B" channels. These channel types are very stable and resistant to disturbance, and currently show few signs of significant downcutting. Where these channels meet the Williamson River Valley or the marsh, they flow out of their confining canyons onto valley sediments. These more sensitive channel segments (where not already ditched) do show signs of downcutting. The causes of the downcutting are likely complex and are a combination of heavy agricultural use, effects of roads and railroad grades, and the lowering of the base level of the Williamson River at Klamath Marsh by cyclic drought and diversion of natural flows.

The remaining stream systems in the Williamson River watershed are low gradient intermittent and ephemeral drainages with discontinuous channels. Most of these systems have downcut channel segments, but the segments are discontinuous, with limited localized effects, and appear to have been in place for several decades They are now widening their channel bottoms to establish a new, more stable channel form. Erosion rates appear to be in excess of those assumed under reference conditions.

Reference Conditions

Prior to the human influences of timber harvest, road construction and livestock grazing, erosion processes associated with water were basically the same as today. Stream banks were the primary source of sediment, the major difference being the rate of erosion. Stream bank vegetation is assumed to have been more continuous, with deep rooted species such as willow and sedge/rush communities more prevalent. Aggressively eroding stream banks, although present, are assumed to have been short, discontinuous sections with little overall effect on the system as a whole. The meadows were well vegetated, with native grass species supplying a well formed root mass, protecting the soil from the erosive forces of major storm events and annual spring runoff.

Accelerated erosion rates were associated with the natural disturbances of fire and drought. The overall impact of these events are assumed to have been less frequent and significantly less intense than the modern disturbances of timber harvest, grazing, and road construction.

Although this is a fairly reasonable picture of the watershed in the early 1800's, clues to the geologic history suggest a much more dynamic environment. The elevation of open water in the marsh, as indicated by terrace deposits, was at least 20 feet above the current level. The Williamson River valley shows signs of multiple channel locations. The river channel at Kirk appears to have occupied several now abandoned channels in well dispersed locations. There are indications that now intermittent streams were perennial and directly connected to the river. All of these conditions appear to have existed in the period of time between the eruptive phase of Mt. Mazama and the present. This suggests that the climate, and therefore erosion processes, have been variable in the recent geologic past.

Synthesis and Interpretation

The water transmission characteristics of the soils, along with the subdued topography, limit the erosive effect of water. Natural and man-made features that concentrate surface water on steeper slopes or areas of unprotected soils such as stream channels, system and non-system roads, logging skid trails, and livestock trails, create the opportunity for erosion to occur.

The majority of the watershed is composed of soil types in Hydrologic Group "A" (Winema National Forest SRI, 1979, page 142) which have a low runoff potential. The gentle slopes of the watershed support roads with minimal gradients (2% to 4%). Storm runoff from such roads in these soils is minimal. Infiltration rates are high enough to eliminate overland flow except in the most extreme cases. Storm runoff down the road surface or in the roadside ditch may occur during rapid snowmelt or intense summer thunder storms, on short pitches of road with grades in the 5% to 6% range or higher. Significant erosion damage is rarely a result of such runoff.

Soils in the southern and eastern portions of the watershed are of Hydrologic Group "B", which has a moderate to low runoff potential. The factor controlling the runoff potential of these soils is overall depth. Areas of moderate runoff potential are not extensive within this group, generally occurring in small isolated areas Again, low gradient road systems limit the potential for significant erosion events.

Scattered throughout the watershed, "G" type (meadow) soils (Hydrologic Groups "C" & "D") have a slow to very slow water transmission rate and do have a high runoff potential. Roads built at ground level in this soil type often function as artificial stream channels, and have at times resulted in accelerated erosion rates and unstable channel conditions. The single biggest concentration of "G" soils is the Klamath marsh and associated grasslands, where roads are limited, gradient is very low, or they are located on raised levees. Most system roads cross meadows perpendicular to the meadow. These road segments are generally fills on top of the meadow surface and do not function as stream channels, but rather tend to concentrate surface flow to a culvert location, and may increase water velocities, causing accelerated erosion rates for short distances above and below the culvert.

Many of the roads associated with meadows are not maintained system roads, but roads created by hunters and wood cutters. These routes tend to run the length of the meadows, and commonly are initiating factors for gullies or destabilizing existing channels. Well established livestock trails have the same effect as these low standard roads. The mechanism appears to be repeated vehicle traffic or livestock use removing the stabilizing vegetation, and exposing bare ground to the erosive power of the spring runoff. Once erosion begins, it continues until vegetation can again capture the site and stabilize the soil. With repeated annual impacts from vehicles or livestock, and the further complication of extended drought, the erosion can and has become fairly dramatic. Examples in the Williamson watershed include Davis Flat on Jack Creek, Haystack Draw and the Bull Pasture, McCarty Meadow on Mosquito Creek, Long Prairie on Rock Creek, and near the mouth of Aspen Creek.

The low gradient natural stream channels associated with grasslands and meadow vegetation have received substantial use by livestock since the late 1800's. This activity has destabilized channel banks by physically breaking them down, and by removing the stabilizing vegetation. This impact has taken place on whole reaches of many streams. Once destabilized, the channels begin a long process of adjusting their channel geometry to handle the additional sediment and establish stabilizing vegetation. A good example of this process is the Williamson River. The river valley has been heavily used by livestock for 70 plus years. Virtually all segments show signs of accelerated bank erosion and the channel adjustments necessary to accommodate the additional sediment. The channel has widened, become shallower, moved laterally in its valley, increased local gradients by cutting off channel meanders, and lost contact with its flood plain. Where livestock grazing continues today, the river displays all these ongoing adjustments. On segments where livestock have be excluded or appropriately managed in recent years, the channel is trending to a more stable condition.

Improved livestock grazing management and the end of drought conditions in the last several years has gone a long way to starting the natural healing process on most gullied meadows and destabilized channel segments. Without repeated disruptive impacts, erosion rates will return to base levels on most stream systems without human intervention. Erosion control structures have been placed in several locations (Telephone Draw, Bull Pasture, Jack Creek). The design of these structures is generally inconsistent with the proper function of the system in which they are placed, and have actually contributed to destabilizing of the channel banks immediately up and downstream of the structures.

The low gradient and discontinuous nature of the most impacted streams and meadows limit the movement of sediment generated from the downcutting process. Sediment is generally deposited immediately downstream of the channel cutting, or is carried through a short canyon segment and deposited in the next meadow. In general, the stream systems of the Williamson River watershed are currently stable or improving their condition, but remain sensitive to above normal runoff events or disruption of the recovering riparian vegetation. The downcut channel segments have localized effects, but have no significant affect on the overall hydrologic function of the systems.

Recommendations

Priority should be given to stabilization of the actively eroding banks of the Williamson River and those segments of tributaries that are adding elevated levels of sediment directly to the river. In most cases these will only be the tributary channel segments immediately adjacent to the river. Bank stabilization activities should focus on those locations where the channel is threatening to cut off a meander and increase local channel gradients. Stabilization techniques should include bank armoring for short term control of bank erosion and the reestablishment of native vegetation to return the channel to long-term stability.

The second priority is the restoration of eroding segments of the intermittent systems that contribute spring flows directly to the river and marsh. The emphasis here should be the elimination of the destabilizing factors, and the encouragement of the natural healing process. In the case of gullied meadows, this may include diverting flows from gullies to older natural channels where practical. The establishment of vigorous native riparian vegetation is the number one key element in any restoration.

Identify all locations where system roads are located within riparian zones and meadows. Where signs of accelerated erosion rates are present, evaluate the opportunity to first remove the road, second distribute the water energy causing the erosion, and third retard the accelerated erosion with vegetation or other materials. Where the road has restricted the passage of flood level flows to one location (single culvert), consider developing additional flow paths to allow utilization of the entire flood plain above and below the road restriction. Where hunters, wood cutters, or livestock have eliminated meadow vegetation, starting the gully forming process, consider barring future vehicle or livestock access, relieving the soil compaction, and encouraging establishment of native meadow vegetation.

III HYDROLOGY AND STREAM CHANNELS

Issue

The hydrologic function of the Williamson River basin has changed over time, resulting in less water being retained in the system later in the year.

Key Questions

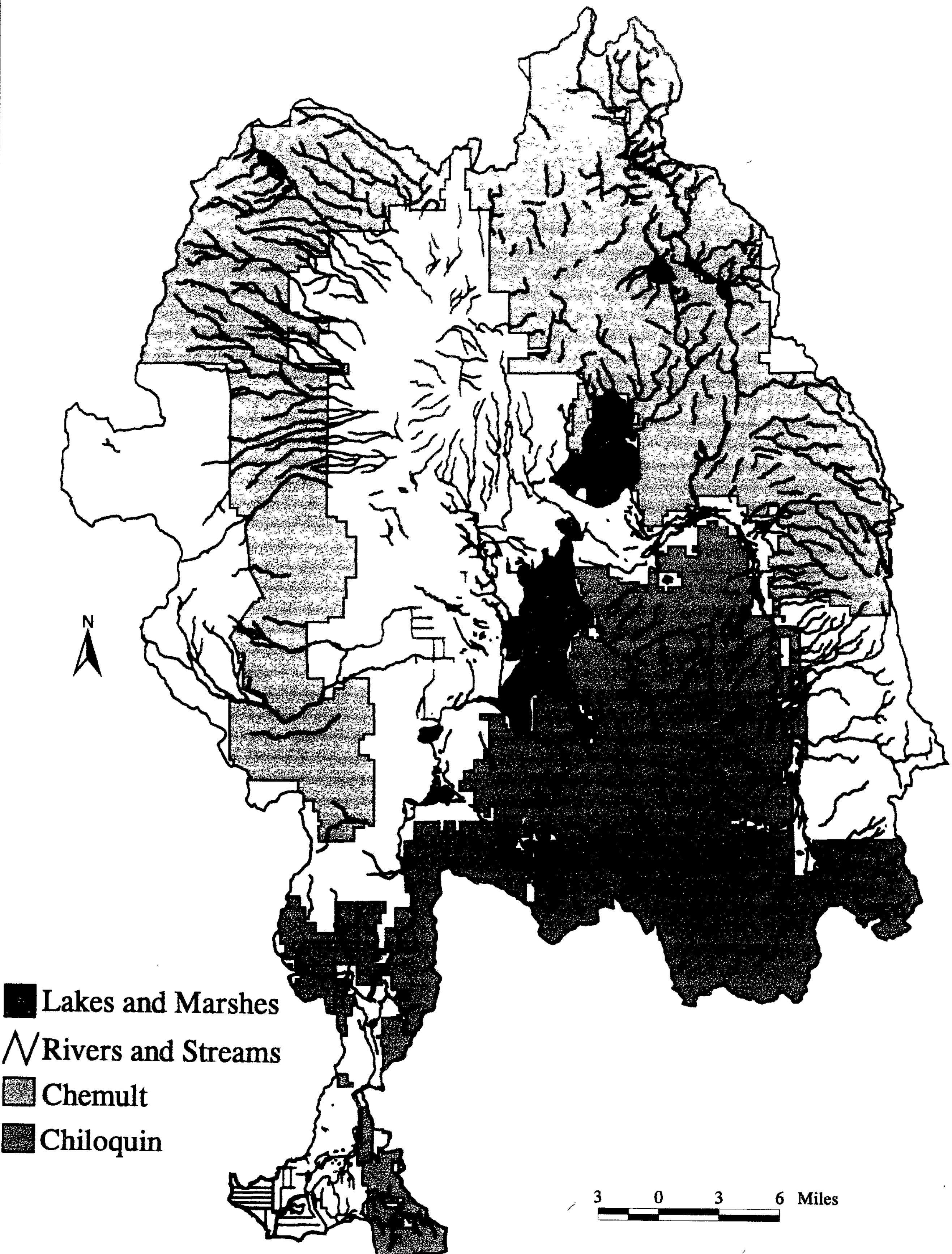
1. Do harvest practices adversely affect water yield?
2. How has grazing affected stream channel conditions?
3. How have water rights of private landowners affected water yield and timing and duration of downstream flows?
4. To what extent have diversions, both public and private, affected the watershed?

Characterization

The Winema GIS data base includes 32 complete subwatersheds within the Williamson River basin. Four distinct watersheds define the Williamson River (1801020101Z Williamson Above the Marsh, 1801020102Z Williamson in the Vicinity of the Marsh, 1801020103Z Williamson Above Confluence of the Sprague, 1801020104Z Williamson Above Upper Klamath Lake). Ten separate subwatersheds are tributary to the Williamson Above the Marsh (1801020101A Jack Creek, 1801020101B Long Prairie, 1801020101C Jackson Creek, 1801020101D Deep Creek, 1801020101E Sand Creek, 1801020101F Williamson Headwaters, 1801020101G Wildhorse Creek, 1801020101H The Bull Pasture, 1801020101I Haystack Creek, and 1801020102M Dillon Creek). Fifteen subwatersheds are tributary to the Williamson in the Vicinity of the Marsh (1801020102A Sand Creek, 1801020102B Scott Creek, 1801020102C Pothole Creek, 1801020102D Bear Creek, 1801020102E Silent Creek, 1801020102F Desert Creek, 1801020102G Cottonwood Creek, 1801020102H Sink Creek, 1801020102I Miller Creek, 1801020102J Lost Creek, 1801020102K Shoestring Creek, 1801020102L Mosquito Creek, 1801020102M Big Spring Creek, 1801020102P Skellock Creek, and 1801020102Q Yoss Creek). Two subwatersheds flow into the Williamson Above the Confluence of the Sprague; (1801020103A Hog Creek and 1801020103B Spring Creek). 1801020105Z Pumice Desert Basin is a closed basin subwatershed in Crater Lake National Park, and likely drains through the groundwater table to Desert Creek Subwatershed.

The GIS data base shows 1,480 miles of stream in the study area, for a stream density of 1 mile per square mile of land area (see Hydrology map next page). This reflects a range of stream densities from

Hydrology


N
Lakes and Marshes
Rivers and Streams
Chemult
Chiloquin
3 0 3 6 Miles

2 5 miles per square mile to a low of 0.5 miles per square mile. In general, steam systems that drain the high country of Yamsay Mountain and the Cascades have densities greater than the average, and those draining the lowlands have densities below the average. The higher density subwatersheds reflect the higher precipitation and steeper topography associated with Yamsay Mountain and the Cascades. Here snowmelt and storm runoff moves over the surface and through the soil profile to the stream systems and down to the Williamson River Valley. The lowland stream densities indicate that snowmelt and storm runoff move primarily through the soil profile and groundwater table to the valley bottom. Of the total stream miles, 20% are classified by the USGS as perennial stream segments. These streams drain the highlands of the watershed.

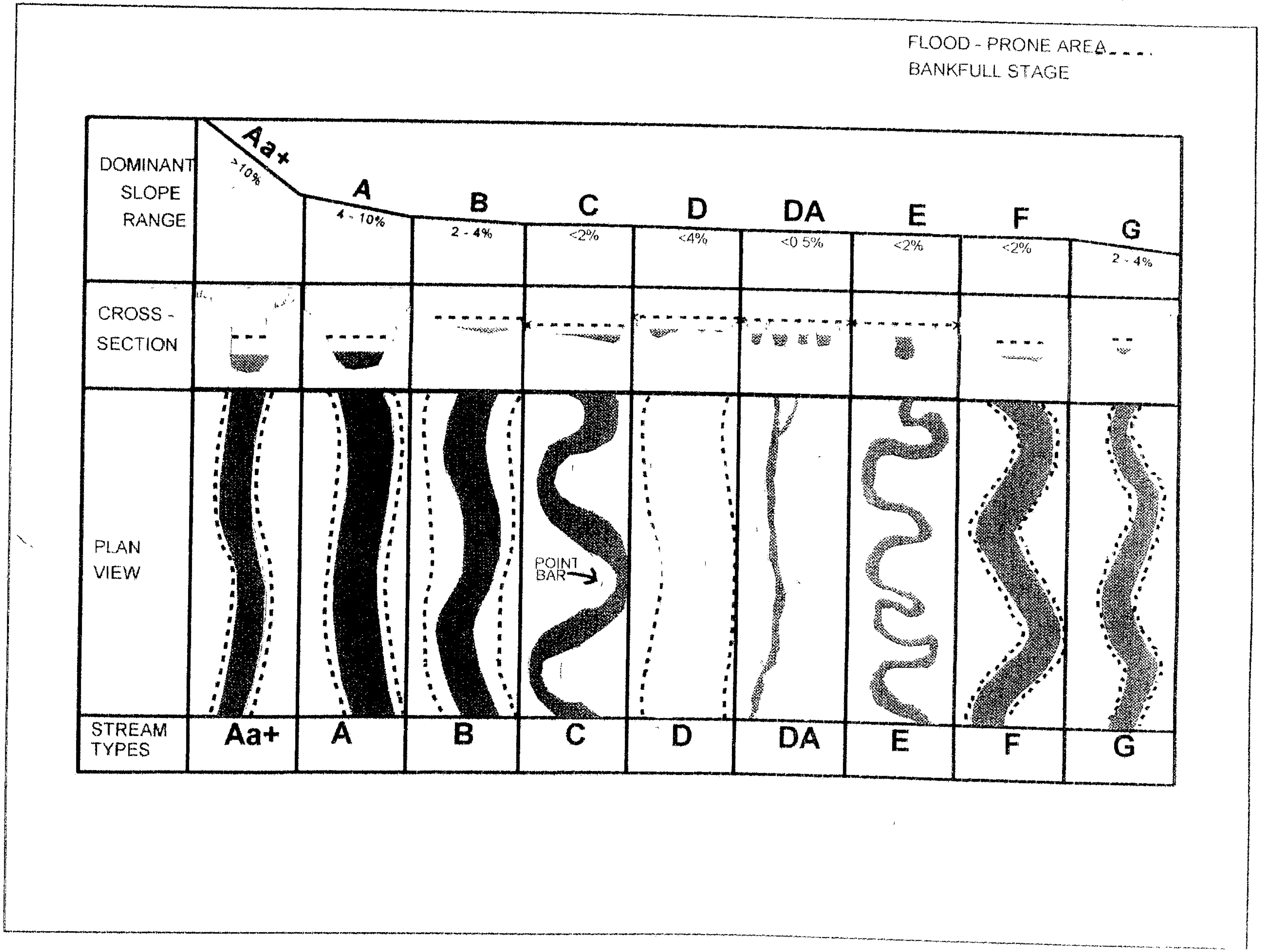
Stream types draining the highlands classify primarily as Rosgen stream type "B" (see figure next page). The most common classification is estimated to be B3. These streams have a low sensitivity to disturbance, excellent natural recovery from disturbances, low sediment supply, low stream bank erosion potential, and moderate controlling influence from stream bank vegetation. As these streams near the valley floor, they generally make the transition to "C" stream types and the component of rock in the channel is reduced. These steam segments have very high sensitivity to disturbance, fair to good recovery from disturbances, high sediment supply potential, very high stream bank erosion potential, and very high controlling influence from stream bank vegetation. As these same stream systems move out onto the valley floor they again transform to Rosgen "E" or "C" stream types. The most common classifications are estimated to be E5 or E6 and C5 or C6. These channels have very high to extreme sensitivity to disturbance, good (E) or very poor (C) recovery potential, moderate to high sediment supply potential, very high to moderate stream bank erosion potential, and high to very high controlling influence from stream bank vegetation.

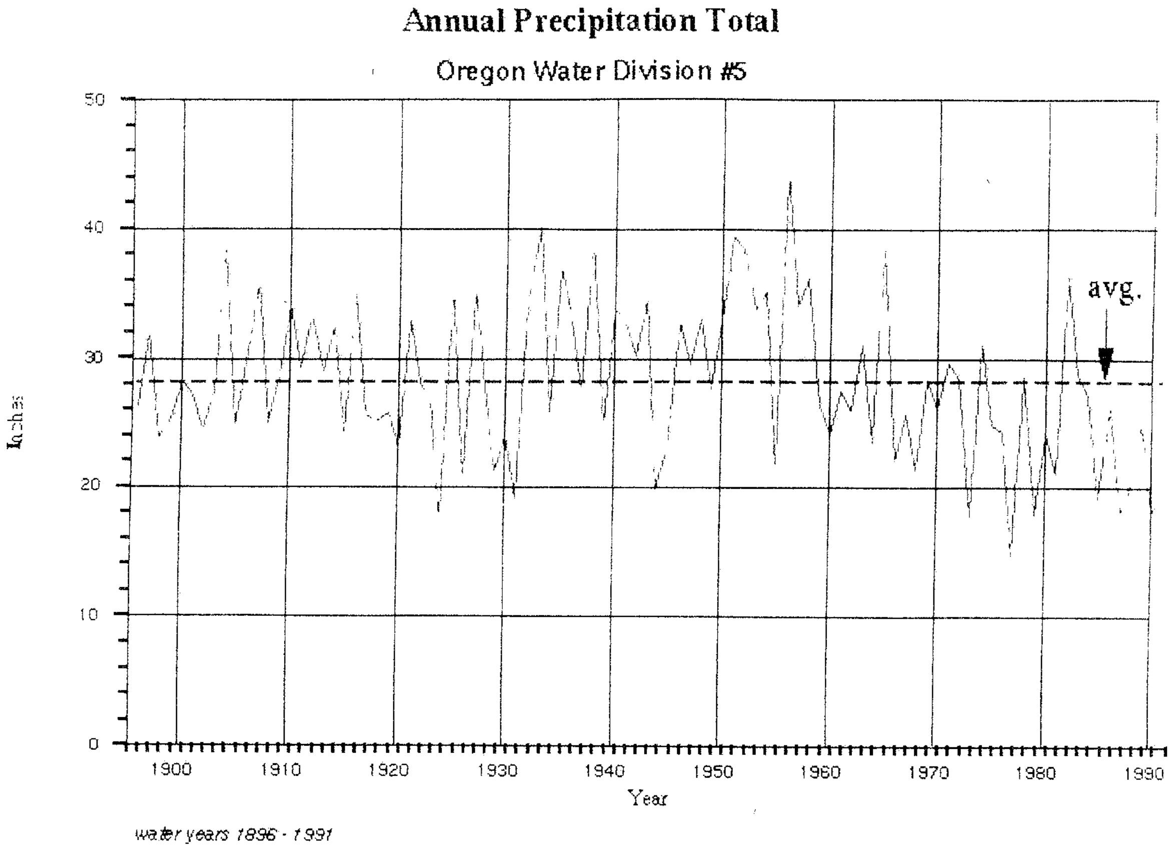
The streams that drain the lowlands are primarily "E" or "C" stream types, from their origins to the Williamson River or the Marsh. These streams often have segments where a stream channel is not evident This is usually associated with very low gradient meadow sections. These systems are intermittent in nature, although some have short perennial segments associated with local groundwater springs.

The Oregon Climate Division precipitation data for Oregon Water Division #5 (see graph, page after next) shows an average annual precipitation for a large geographic area, including the Williamson River Basin, of 28.11 inches for the period 1895 to 1992. The maximum annual amount for the same recording period was 44.6 inches and the minimum was 14.64 inches. Precipitation generally comes in the form of snow in the months of November through March, with the snowmelt season being February through June. The important factor displayed in the data is not the amount of precipitation, but the variability from year to year. It is not uncommon for precipitation to vary by 10 to 20 inches from one year to the next. It is also not uncommon for 4 to 6 consecutive years to be significantly above or below the average.

The boom or bust nature of the precipitation is reflected in the variability of total stream discharge amounts, peak flow timing, and minimum flow volumes. In general, peak flows occur during spring snowmelt, but may vary in time by a month or more from year to year. Peak flow volumes will also vary by an order of magnitude between drought and wet cycles. Minimum flows will also vary significantly with streams on the margin between perennial and intermittent, or intermittent and ephemeral, moving back and forth in classification with the weather cycles.

Longitudinal, cross-sectional, and plan vie... of major stream types (after Rosgen 1994)





The base flows in the Williamson river are influenced by several large volume springs including Head of the River and Wickiup. These springs tend to mediate the effect of drought cycles on the Williamson River above the Marsh.

The amount of precipitation in the highlands is considerably higher than at the Marsh and river valley level. The average annual precipitation recorded at Crater Lake is 68.9 inches for the period 1930 to1995. This is 2 ½ times the average precipitation at the Marsh level. There is also variability in totals for these high elevation locations. The Crater Lake data had a high of 100.12 inches in 1950 and a low of 42.08 inches in 1976. The increased levels of precipitation stored as snow in the higher elevation portions of the Williamson River watershed are the source for the basin's perennial streams.

Current Conditions

Currently channels and their riparian vegetation communities adjust to the boom and bust climate environment much as they did before the turn of the century. During drought cycles, the riparian vegetation is stressed, weakened, and in extreme cases eliminated from some locations, making channel banks susceptible to accelerated erosion. A series of wetter years fill the water table, return vigor to the riparian vegetation, and start the healing process at any site where channel destabilization takes place. The major difference is that today many of the stream channels are subjected to additional, more frequent disturbance events.

Heavy grazing use since the late 1800's, road construction in and across riparian areas, and diversion of natural stream flows for agricultural and other purposes have intensified and extended the effects of the natural disturbance of cyclic drought. Season-long, and in some cases year-round livestock grazing has worked with drought to broaden the extent of channels where riparian vegetation has been eliminated These same grazing activities tend to delay the natural recovery of riparian vegetation during wetter climatic periods. Roads in and crossing riparian areas have restricted the ability of the streams to utilize their entire valley bottom to adjust channel geometry in response to destabilizing factors. Streams where flood flows are restricted to a single path through a culvert in a road fill generally result in channel bed erosion above and below the culvert. Diversions of stream flows from natural channels has reduced some streams' ability to maintain their sediment balance, support a vigorous riparian community, and maintain groundwater recharge function downstream of the diversions.

The Rosgen type "A" and "B" channels draining the highlands have largely escaped the disruption to riparian vegetation and channel instability associated with grazing, road construction, and diversions. These stream types do not offer forage for livestock, nor topography favorable for road location. The exception is the failure of road fills where roads have crossed channels perpendicular to the run of the stream. Where these streams make the transition to "C" and "E" type channels as they move out onto the valley floor, they have suffered all the effects of human land use practices. The largely perennial streams have been heavily diverted for agricultural use.

The gentler sloping lowlands drained by discontinuous "C" and "E" channels offer the bulk of the suitable livestock forage in the watershed, as well as some of the more favored road locations. The streams in these areas all display the effects of long term grazing practices and multiple road intrusions into riparian areas. The proportion of these "C" and "E" channels with segments of destabilized "G" and "F" channel types are significantly higher than assumed in the reference era.

Riparian vegetation along the "A" and "B" channel types included conifers, alder, and some limited aspen occurrence. The current vegetation conditions serve the stability needs of these channel types. The "C" and "E" channel types and their unstable counterparts, "G" and "F", have had their natural riparian vegetation of rush, sedge, willow, and vigorous aspen communities replaced with bare ground, non-native grass species, or in some extreme cases, conifer tree species. The dense root mat of the sedge, willow, and young vigorous aspen communities are key elements in the stability of these systems. The replacing vegetation is less able to resist the erosive forces of flood flows or even normal spring runoff.

Reference Conditions

There is little indication that precipitation of the Williamson River basin has changed significantly since the reference era. Precipitation, as today, was highly variable and included several year periods of drought as well as periods of above average annual precipitation. The channels and their riparian vegetation communities adjusted to this boom and bust environment. During drought cycles, the riparian vegetation was stressed, weakened, and in extreme cases eliminated from some locations. In these circumstances, the channel banks would be susceptible to accelerated erosion if subjected to an above average runoff event. The possibility of such an event following a drought cycle is high, as demonstrated by the existing precipitation record. A series of wetter years filled the water table, returned vigor to the riparian vegetation, and started the healing process at any site where channel destabilization took place.

The stream channel types represented during the reference era included Rosgen type "A" and "B" channels draining the highlands, that transitioned into "C" and "E" as they moved out onto the valley floor. The gentler sloping lowlands were drained by discontinuous "C" and "E" channels, broken by short segments of "B" channels, in moderately incised canyons between meadow sections. In most cases, these relatively stable channel forms likely included short segments of destabilized "G" and "F" channel types.

Riparian vegetation along the "A" and "B" channel types included conifers, alder, and possibly some limited occurrence of aspen. Vegetation had little effect on the overall stability of the channels; however, the root network in the stream banks did tend to limit the localized erosion of bank material. The "C" and "E" channel types supported riparian vegetation including deep rooted sedge and willow in the meadows, and aspen, conifer, and cottonwood in the narrow, low gradient valley segments. The dense root mats of the sedge, willow, and young vigorous aspen communities were key elements in the stability of these systems. Riparian vegetation struggled for a foothold on the actively eroding stream banks of the short "G" and "F" channel segments.

Synthesis and Interpretation

Increases in total vegetative cover due to wildfire suppression likely has some effect on total water yields in the study area; however, vegetation is only one factor in the determination of water yield. The major factor in every case is the amount, type, and timing of precipitation. Other factors include slope angle, land form, geology, soil characteristics, stream channel density and gradient, depth to water table, watershed aspect, average air temperatures, and local differences between total potential and actual evapotranspiration.

A water balance analysis (S. Mattenberger 1995) for the Chiloquin area, developed from precipitation and temperature data collected between 1942 and 1971, indicates a total moisture deficit of approximately 4 inches. This deficit indicates the difference between the soil moisture available to plants during the growing season and the amount of water the plants would use if supply was not limited. The months of April through October all show a moisture deficit. That is, the input to the soil moisture pool is less than the plants could use. Any gains in water yield from removal of vegetation will tend to reduce the period of moisture deficit. This may make some additional groundwater available for release to streams in the months of April and/or October. Stream flows in the summer months are not likely to change. Intermittent streams would not be changed to perennial, nor would base flows in perennial streams be increased.

The amount of forest cover may have a more significant influence on the accumulation of snow and the timing of snowmelt, and therefore the timing of peak flows and late summer base flows. Forest cover open enough to allow direct sunlight to the forest floor will tend to melt the snowpack more rapidly than under a closed canopy. This same open forest canopy will allow more snow to collect on the forest floor. This effect is also dependent on variables such as slope, aspect, elevation, and weather conditions. A reduction in vegetative cover on the order of 50% over the majority of a watershed may cause an initial increase in peak flows a few weeks earlier in the spring melt season. Frequent maintenance of this open condition would be required to have a meaningful effect on overall hydrologic function. The most benefit would occur when a balance in forest canopy allows maximum snow accumulation during the winter months and at the same time maximizes the melt time in the spring and into the early summer.

Effects of improper grazing practices on the stream channels are concentrated on the "C" and "E" channel types in the Williamson River Valley, Klamath Marsh, and the meadow sections of the lowland streams in the eastern half of the river basin. The effects have included soil compaction, exposure of bare soil to erosion processes, destabilization of stream banks by removing the deep rooted vegetation and physical break down of bank structure. These effects tend to contribute to accelerated erosion rates and channel downcutting and widening, and the creation of the unstable "G" and "F" channel forms.

Grazing has not been the sole factor in modifying channel conditions. Heavy season-long grazing activities, along with extended drought conditions, make the meadow environments and the natural channels more susceptible to above normal or high intensity runoff events. Heavy runoff events, along with sparse vegetative cover and weakened root mass, accelerate erosion rates and destabilize channels, which can be aggravated by continued grazing pressure. Natural recovery of these destabilized channel segments is a long process and requires significant channel bank erosion and adjustment to local stream gradient.

On the Williamson River, cattle grazing remains a primary land use on much of the private lands. The river banks are frequently devoid of the natural stabilizing vegetation (willow and deep rooted sedge), the channel is often wide and shallow, and the channel banks are aggressively eroding during high flows. Flood flows no longer have access to the valley floor to dissipate energy and control erosion rates. Continued use of the river banks by domestic livestock tends to maintain this unstable condition along with high sediment loads. Continuous grazing use has retarded the natural recovery of the channel in locations where this occurs. Segments of the river that have had livestock grazing excluded, or improved management practices put in place, have started the healing process. Point bars have revegetated with dense sedge communities, the channel has narrowed and deepened in the meander sections, and willow has reestablished in the upper portions of the point bars.

Haystack, Telephone, and Skellock draws, the Bull Pasture, Jack, Mosquito, Big Spring, Yoss, and Hog Creek drainage systems all have segments of downcut channels that appear to have been caused by a combination of heavy grazing use, vehicle traffic in the meadows, drought, and heavy runoff or high intensity storm events. The curtailment of grazing use in the last several years, along with the easing of drought conditions, has allowed many of these channel segments to begin the healing process.

Most of the perennial and long term intermittent stream systems in the Williamson River basin have been captured for use as a source of water for pasture irrigation or other agricultural use. The full flow of the upper Williamson River is diverted for use by the Klamath Forest National Wildlife Refuge in the northern portion of the refuge. The result of these diversions has been to eliminate or dramatically curtail the surface water connection between tributary streams and the Williamson River and Klamath Marsh. This break eliminates the infusion of high quality, cool water during the summer months. The diversion of the river flow away from the lower marsh has significantly altered the historic marsh conditions. The amount of open water has been greatly reduced and replaced with tule marsh and grassland. This diversion has also likely had an effect on summer flows in the river below the marsh In recent years the river frequently goes dry at the Kirk gage station in late summer. This event, although likely present in the reference period, is believed to have taken place less frequently and for a shorter duration.

Jackson, Irving, Aspen, Deep, Big Spring, Scott, and Sand creeks are the most obvious examples of the diversion of once tributary streams to the river and marsh. Jackson, Irving, Scott, and Sand creeks have lost all surface connection to the Williamson. The connecting channels have been heavily modified by agricultural use. Deep Creek has much of its flow diverted into the Aspen Creek drainage during the spring and summer months. Deep Creek does maintain a surface flow connection to the river during early spring high flows before the diversions are activated, and during above normal precipitation cycles. Sand Creek shares half of its flow with Scott Creek, and the sum of their flows are utilized to irrigate pasture lands in the northwestern portions of the marsh.

Entrenched channel segments in Haystack, Skellock, and Telephone Draws, the Bull Pasture, and Jack, Mosquito, Big Spring, Yoss, and Hog Creek drainages locally lower the water table, or accelerate the seasonal lowering of the water table, which may result in the loss or narrowing of riparian vegetation zones. This may include changes in grass species, a narrowing of the meadow through replacement by conifer forest, or in extreme cases, the slow conversion of the total site to a conifer forest. No cases of a full site conversion were observed in field investigations.

Recommendations

Do not enter into a program of reducing upland vegetation for the sole purpose of increasing stream flows or the restoration of meadow environments. Initially, vegetation management for the benefit of hydrologic function should focus on the establishment of vigorous native riparian vegetation on stream segments that have been degraded by past management activities. The main emphasis should be on encouraging the natural recovery process. A long-term objective to modify upland vegetation to maximize snow accumulation and retention may benefit late season stream flows.

Mitigation of soil compaction for the benefit of hydrologic function is generally not necessary. Meadow lands are the exception, if compaction is barring the natural recovery of riparian vegetation. If roads are removed, the compaction of the road surface should be mitigated.

Channel restoration activities should focus on the Williamson River first. Restoration activities along the river should focus on appropriate grazing methods compatible with riparian recovery, and reestablishing stabilizing vegetation. In most cases, this will require negotiations with private landowners to identify joint projects.

National Forest holdings along the river should be used as test sites to develop the most efficient way to reestablish willow and sedge growth on the raw, actively eroding channel banks. The proven process can then be demonstrated to private landowners, and with their cooperation, expanded along the full length of the river.

A cooperative effort should be undertaken with the managers of the Klamath Forest National Wildlife Refuge to evaluate the possibility of returning the upper Williamson River flow to its natural path through the marsh.

Road crossings of the type "A" and "B" streams that drain the high country of Yamsay Mountain and the Cascades should be evaluated for fill design and culvert size and placement. The Deer Creek, Lower Swiss Spring Creek, and Swiss Spring Creek crossings of the Miller Lake Road (9772) should be evaluated for the opportunity to return natural flows to the stream segments below the road. The road fill and culvert design of the 2308 crossing of Pothole Cr. should be evaluated in light of the fill failure on Bear Creek. The design of the 49 road crossing of Jackson Creek should be altered to allow for increased flood water passage through the road fill.

The type "C" and "E" segments of the basin's perennial streams should be evaluated for opportunities to return diverted flows back into the natural channel. This will require negotiations with the holder of the water rights. Priorities should be given to Sand, Scott, Big Spring, Jackson, Irving, Aspen, and Deep creeks. The 4648 road crossings of Deep and Aspen creeks should be evaluated for their ability to distribute the flood flow water across the full valley bottom.

The "C" and "E" type streams that drain the lowlands need to have the riparian vegetation protected from degradation. This may require the elimination of livestock grazing activities during drought conditions. The establishment of vigorous willow communities should be a priority wherever remanent plants exist. Road crossings should be evaluated for adequate design and drainage. Wherever possible, flood flows should not be restricted by road fills and should have access to the full valley width for energy disbursement and maintenance of riparian plant communities. The following crossings are of particular interest:

88 and 330 spur crossing of Mosquito Creek
86 crossing of God Creek
83 crossing of Mosquito Creek
49 crossings of Skellock Draw, Clover and Meadow Creeks
4990 crossings of Clover and Meadow Creeks
43 crossing of Hog and Yoss Creeks
4344 crossing of Yoss Cr
4582 crossing of Telephone Draw

The destabilized "G" and "F" channel segments of these same streams need site specific evaluation to identify opportunities to:

Return flood flows to the meadow surface by diversion to an older channel segment or dispersal of flood flows across the full meadow
Protect and enhance riparian vegetation along the length of unstable channel segments
Eliminate or at least reduce livestock grazing impact
Relieve the influence of any road crossing up or downstream
Eliminate vehicle access to adjacent meadows

Areas to consider include:

The lower reach of God Creek
The God Butte reach of Mosquito Creek
McCarty Meadow reach of Mosquito Creek
Little Round Meadow on Mosquito Creek
Rakes and Jamison Meadows reaches of Jack Creek
O'Conner and Sproats Meadows on Jack Creek
Davis Flat on Jack Creek
Meadow Creek above the 4990 road
Meadow Creek below the 49 road
Telephone Draw and The Bull Pasture below the 4582 road
Telephone Draw below the confluence with Haystack Draw
Hog Creek west of Wilson Flats

IV VEGETATION

Issue

The impact of human management activities have altered the vegetative component of the watershed from its reference condition.

Key Question

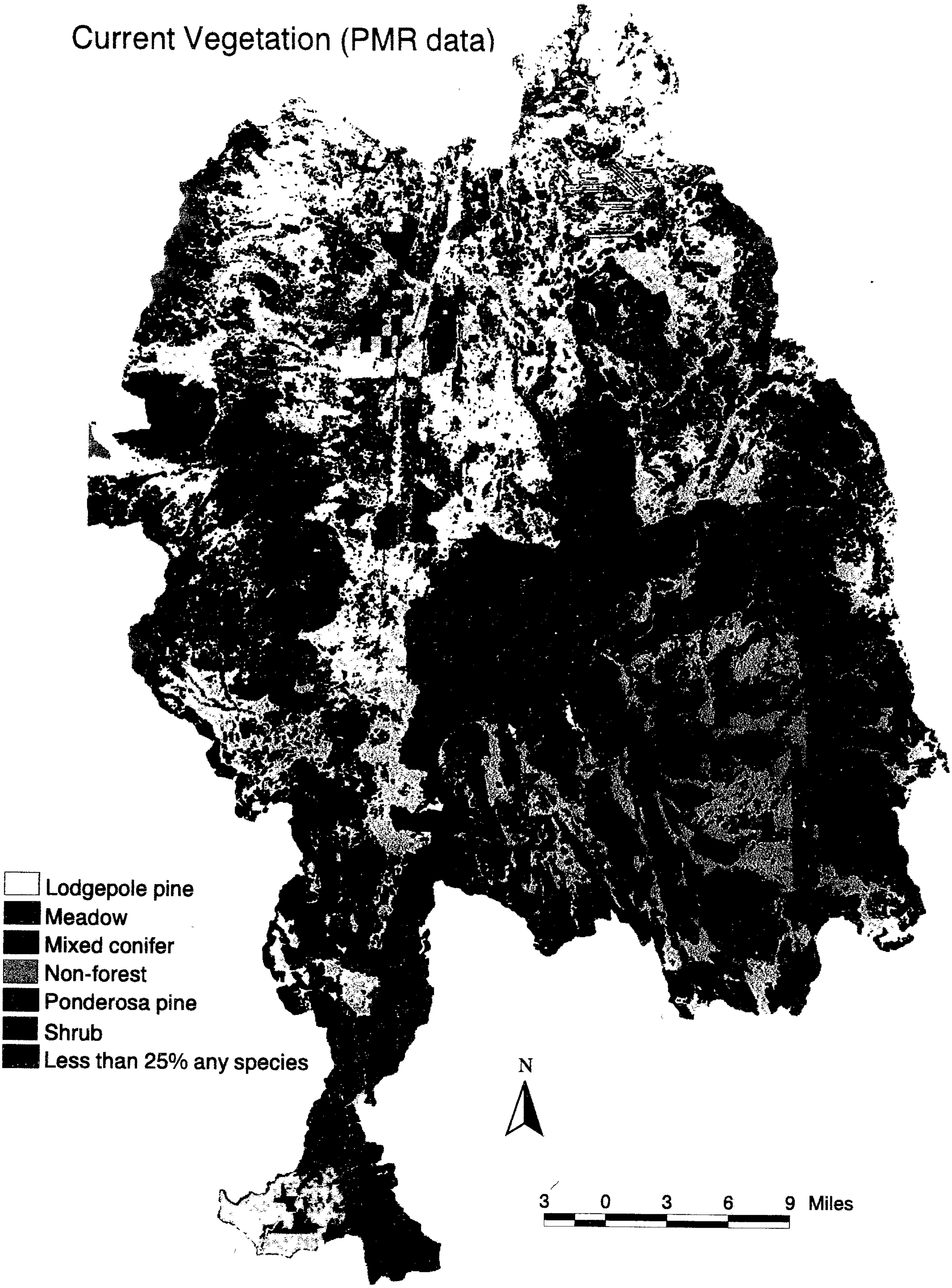
How and why have the upland and riparian vegetation components changed?

Characterization

Vegetation within the watershed is highly variable, ranging from meadows to forests. Forested types are dominantly ponderosa pine, lodgepole pine and mixed conifer. The Current Vegetation PMR data map (map 1) shows the current dominant vegetation as mapped by Pacific Meridian from high elevation photography. This pixel data was washed by a four by four grid to produce the map. Most of the watershed (83 percent) is currently forested on both publicly and privately owned lands. Of that, 33 percent are dominantly lodgepole, 24 percent are mixed conifer, and 23 percent of the acres are ponderosa pine. The table below shows the percentage of other species:

Cover Type	Percent
Ponderosa pine	23
Mixed conifer	24
Lodgepole pine	33
Grass	10
Shrub	4
Juniper	<1
Agricultural lands	1
Other forested	1

The primary factors that determine where a tree species will be located are elevation, topography, moisture, and disturbance factors. Potential natural plant communities have been defined that reflect the vegetation that would normally grow under these different conditions. The Current Vegetation,


Current Vegetation (PMR data)
Lodgepole pine
Meadow
Mixed conifer
Non-forest
Ponderosa pine
Shrub
Less than 25% any species
N
3
0
3
6
9
Miles

National Forest Only map (map 2) represents the plant species that would dominate FS administered lands within the Williamson River watershed area in the absence of disturbance. These plant communities were mapped for the Winema during the 1970's by Volland (Plant Associations of the Central Oregon Pumic Zone).

A comparison of Map 1, based on high elevation imaging, and Map 2, based on ground mapping, shows a high correlation, with Map 2 having less resolution than Map 1. Map 1 is useful for depicting the current vegetation across the entire watershed. The discussion of historic plant communities in following sections is based upon the potential natural vegetation, so references to historic and current conditions would best be compared to Map 2.

As disturbance interacts with vegetation and other factors, different seral stages appear. For instance, bare ground in an area with a potential vegetation of dry site non-riparian lodgepole pine may pass through several seral stages before the lodgepole pine is present. It may start as a grass/forb stage, progress through a brush stage, then fill in with lodgepole pine seedlings, and eventually mature to old growth. A fire occurrence at any of these stages could revert the area back to an earlier stage. Because of the frequent fire which occurred historically in this watershed, many of the stands were continuously in an early seral stage, rather than old growth. In this example, since lodgepole pine does not withstand fire, the lodgepole type probably had very little lodgepole present historically. It would have been a lodgepole savannah or scattered in small pockets, rather than the continuous presence it now shows. The exclusion of fire, and the presence of harvest as a disturbances, has allowed for changes in vegetation types, structures, and patterns on the landscape. The understanding of potential natural plant communities and natural disturbances allows us to recreate a probable historic landscape. This will be discussed in more detail in the individual plant community discussions.

On public lands administered by the Forest Service, vegetation within the Williamson River watershed analysis area can be divided into four major potential plant community types: lodgepole pine (26% of watershed), ponderosa pine (26% of watershed), mixed conifer (6% of watershed), and meadow/riparian (1% of watershed). There are also inclusions (less than 1%) of juniper and sage/shrubland. The area is also interspersed with small riparian stringers and meadows.

Thirty-seven percent of the area is in other ownership, notably the Highway 97 corridor, the Klamath Marsh and the Crater Lake National Park. Much of that land is occupied by lodgepole pine. Potential plant community mapping has not been done on these acres.

Fire Ecology

Fire was an important ecosystem process in the Williamson River watershed during the historic era. Some of the critical functions that fire played included:

- ✓ nutrient cycling
- ✓ stand density maintenance/control
- ✓ species composition
- ✓ stand structure regulation
- ✓ stand integrity protection (from wildfire, etc.)
- ✓ insect control (indirect)
- ✓ disease control (indirect)

Currently, fire plays a much different role in these stands. Wildfire suppression organizations have been fairly successful from the 1920's up to the 1990's in excluding fire from the ecosystem. While many facets of the ecosystem are affected by fire exclusion, other management practices such as timber harvest and livestock grazing have contributed to some of the effects. However, there are some ecosystem changes that have been caused principally by fire exclusion. These include:

✓ reduced nutrient cycling
✓ fuel accumulation (and increase in stand replacement wildfire potential)
✓ decrease in fire dependent plant species (aspen, willow, cottonwood, wild cherry, many forbs)
✓ increase in fire intolerant plant species (lodgepole pine, white fir)

Current Conditions

As can be seen by a comparison of maps 1 and 2, the current and potential natural vegetation are nearly identical. The current conditions are described on the basis of the potential vegetation mapping so that they can be easily compared to the recreated historic vegetation conditions.

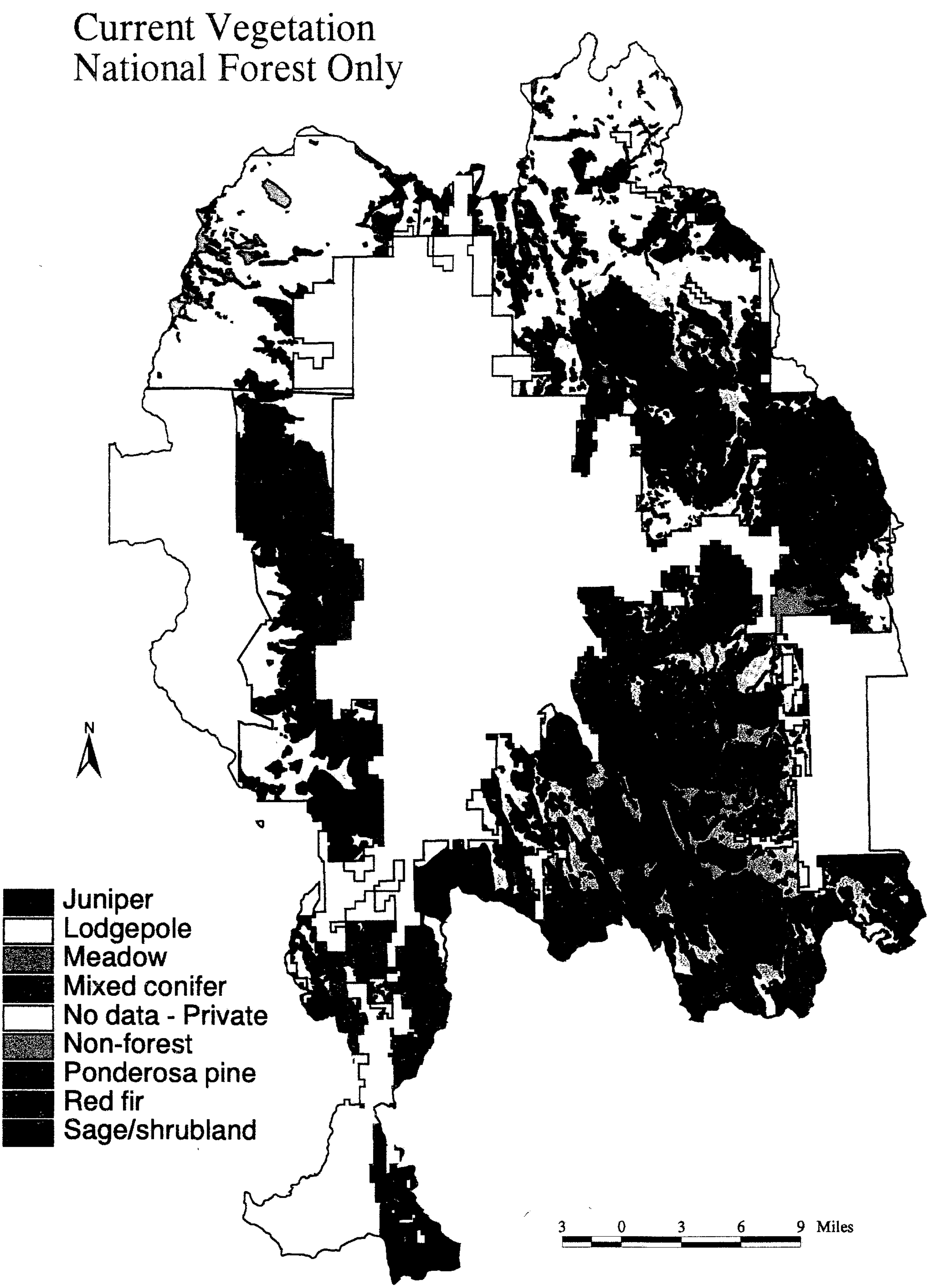
Lodgepole Pine Types

The lodgepole pine community in the watershed can primarily be divided into the lodgepole/bitterbrush (CL-S2-11 and CL-S2-12), lodgepole/needlegrass (CL-G3-11) and lodgepole/manzanita (CL-S3-11) types, with some minor inclusions of the lodgepole/huckleberry, lodgepole/bearberry and lodgepole/sagebrush community types; the lodgepole/riparian associations are discussed separately in the meadow/riparian section.

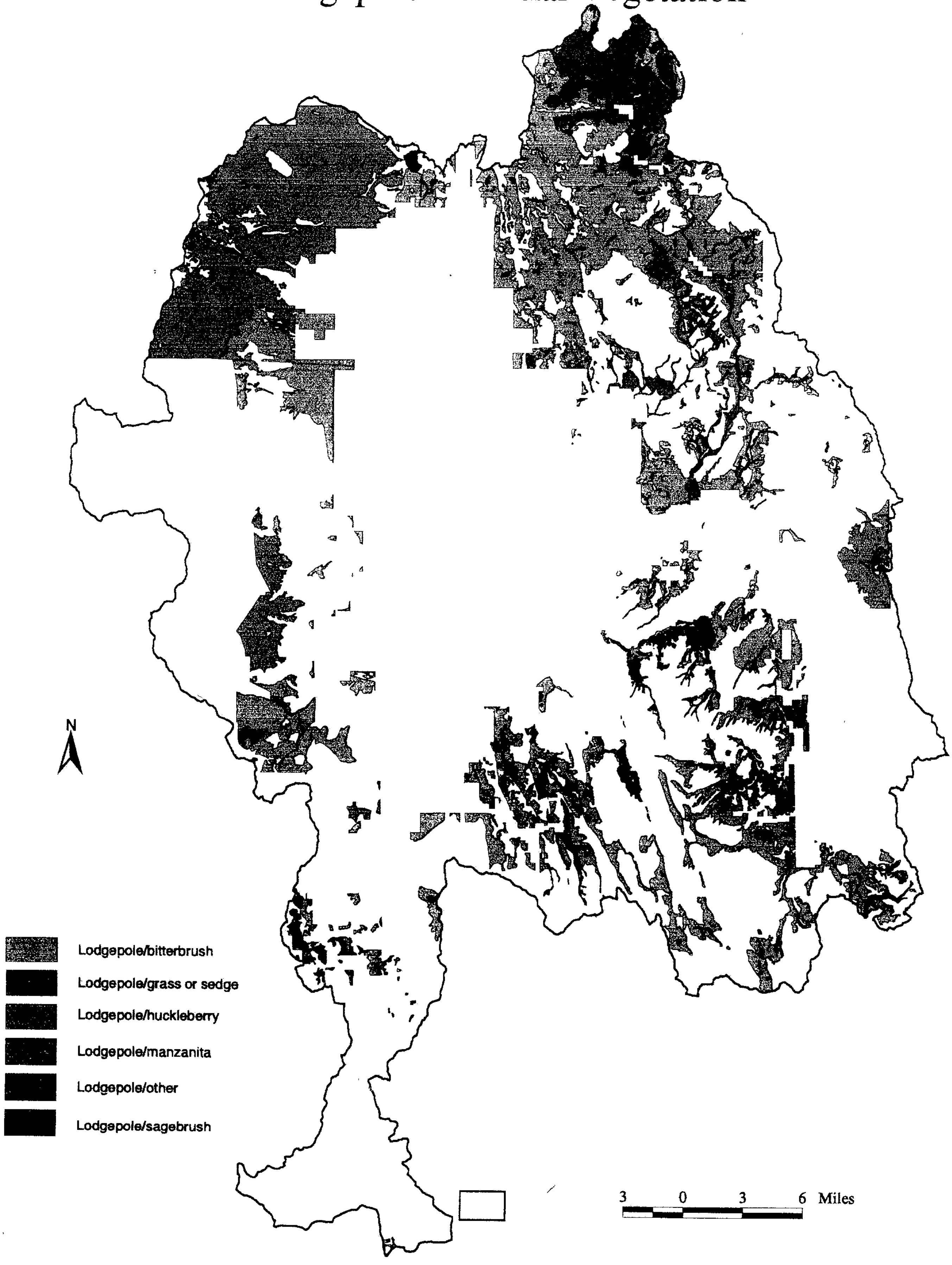
Lodgepole/manzanita

This community type is located on the upper portions of slopes 5,800 to 7,000 feet in elevation on Chemult Ranger District (see Lodgepole Potential Vegetation map). This type is primarily found on the summit of Yamsay Mountain, the northwest corner of the Chemult district surrounding Miller Lake, and adjacent to the eastern boundary of Crater Lake National Park between Scott and Bear Creeks.

The current stands in these areas are old (80-120 years) lodgepole pine stands that contain some mortality from mountain pine beetle, except for stands that have been either regenerated, or simply had the mortality removed. Most of the timber sale activity has been in the area adjacent to the Park, although some activity has occurred in the northern portion of the district. On the western side of the watershed, Shasta red fir, white fir and sugar pine are also components of many of the stands. The top of Yamsay mountain has a large amount of associated white fir which has sustained mortality in the past 10 years due to stress and fir engraver beetle outbreaks.


Current Vegetation
National Forest Only
N
Juniper
Lodgepole
Meadow
Mixed conifer
No data - Private
Non-forest
Ponderosa pine
Red fir
Sage/shrubland
3 0 3 6 9 Miles

Lodgepole Potential Vegetation



Lodgepole/bitterbrush

This community type can be further subdivided into the lodgepole/bitterbrush/fescue and lodgepole/bitterbrush/needlegrass types. The predominate difference between the two is the inclusion of ponderosa pine in the understory of the /needlegrass type. These stands are found on the northern portion of Chemult Ranger District, interspersed with other types along the district panhandle, and as stringers bordering riparian areas where they are adjacent to the wetter lodgepole/bearberry and lodgepole/huckleberry types. These stringer stands are also located on the Chiloquin district. Lodgepole/bitterbrush is the predominant lodgepole type in the analysis area [see Current Vegetation (PMR data) map] when the central privately owned lands are also considered. This type is also located in cold, dry areas where frost is a problem for other species. Slopes range from 0-12%, with all aspects of exposure and generally from 4,200 to 5,700 feet.

The current condition of these stands varies across the watershed. At the north end of the watershed, heavy mortality occurred due to a mountain pine beetle epidemic in the 1970's and '80's. Extensive salvage operations have removed most of the dead material, leaving scattered pockets of dead and down habitat. Many areas have again regenerated heavily to lodgepole pine. The remaining residual stands are composed of trees that did not succumb to beetle attack. Most of these trees are infected with gall rust canker and mistletoe which will tend to infect the emerging regeneration. The same holds true, to a lesser extent, on the Chemult panhandle, except that the residual stands tend to be in healthier condition.

These stands on Chiloquin District, although of a size preferred by bark beetles, have received less beetle mortality (10-50 percent per stand), perhaps because the sites are better or because the stands are not contiguous. In this case, due to absence of historic fire frequency, lodgepole has moved into areas that once were riparian and meadow stringers.

Lodgepole/needlegrass

These community types are primarily located at the northern end of the watershed, surrounded by the lodgepole/bitterbrush type, although a few scattered pockets occur around the watershed. Located on the lower third to the bottom of slopes or in flat basins, these types occupy sites that are cold and generally nonproductive. Frost heaving is common.

Currently the stands on the north end of the watershed have exhibited the same mortality as the lodgepole/bitterbrush stands, due to mountain pine beetle. Because these areas are hard to regenerate, there were less salvage entries compared to the lodgepole/bitterbrush communities. There is still a scattered residual overstory of 80-100 year old lodgepole, with down dead lodgepole and regeneration beginning to come in. The cold associated with frost pockets and frost heaving has slowed down the natural regeneration of these areas. On the southern portion of the watershed the community is in much the same condition as that described for lodgepole/bitterbrush.

Ponderosa Pine Types

There is one major ponderosa plant community type, ponderosa/bitterbrush represented by the CP-S2-12, CP-S2-15 and CP-S2-11 plant communities.

Ponderosa/bitterbrush

The ponderosa/bitterbrush community is located throughout the watershed (see Ponderosa Potential Vegetation map). It occurs in scattered patches located on ridges, knolls and rises that bring it out of the lodgepole dominated frost pocket areas on the north end of the watershed. It dominates the landscape from Sugarpine mountain south, on the east side of the watershed, containing inclusions of the lodgepole pine types discussed above. Along the western portion of the watershed, its range is determined primarily by elevation along the Cascade crest. The community is located between 4,500 and 6,000 feet in elevation in the watershed area, and is associated with smaller amounts of lodgepole pine, Douglas-fir, white fir and sugar pine.

Currently, stands in this community exhibit the results of repeated timber harvest entries and the exclusion of low intensity fire. Almost all ponderosa stands within the watershed were railroad logged beginning in the 1920s. These and subsequent entries tended to remove the larger ponderosa pine, either by regeneration cutting or overstory removal. Some of the stands have been entered two to four times, while some have only had one light removal. Many of the Chiloquin stands had no greater change than what would occur from natural mortality. Because of the increase of smaller trees in the understory, average stand structure has become much smaller, although perhaps 30% of the area retains an old forest overstory structure.

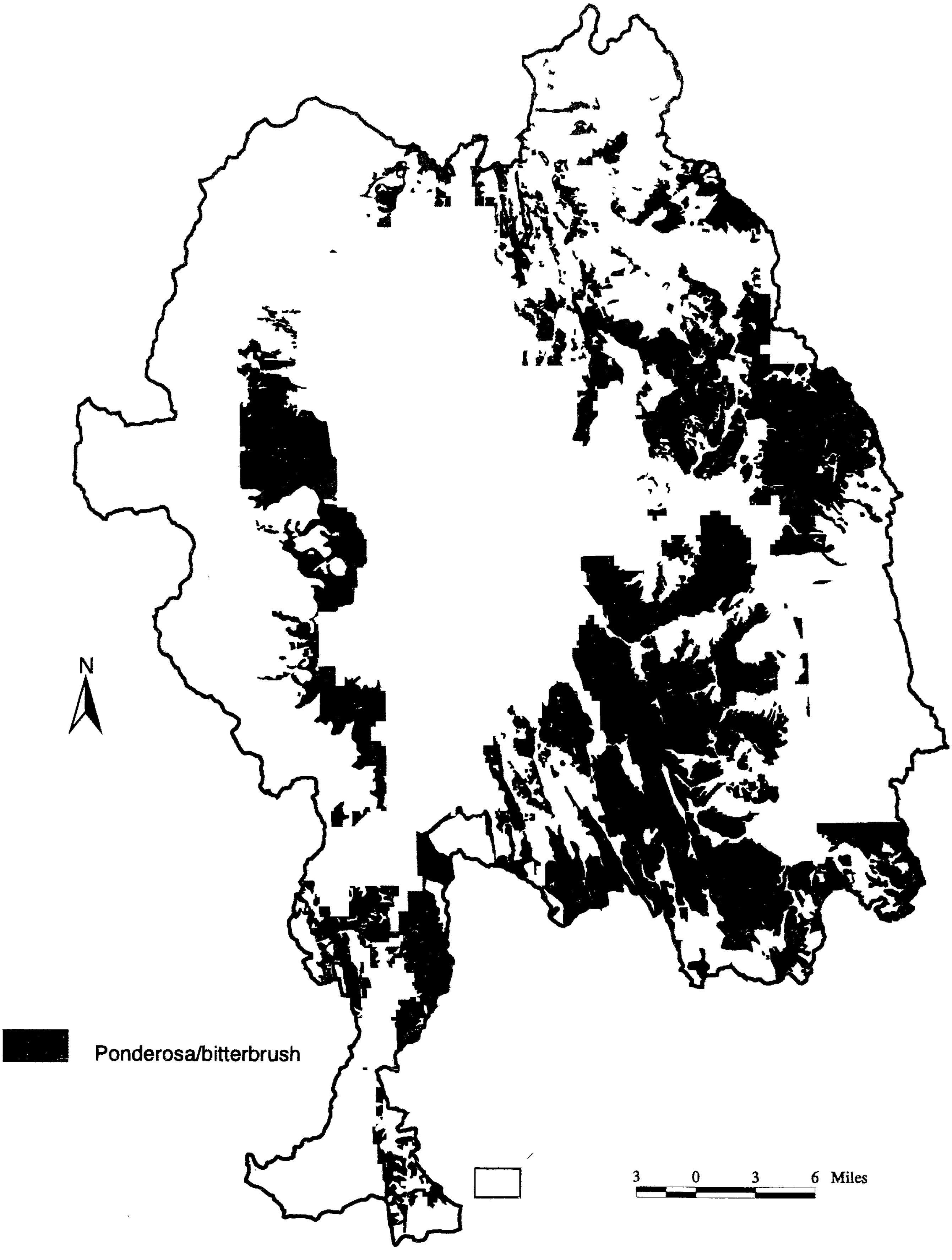
The largest change in stand structure has occurred due to fire suppression allowing the invasion of lodgepole pine or white fir, and the development of a thick ponderosa pine understory. The lack of low intensity fire has resulted in stands that are heavily overstocked in the conifer component. Sue Puddy, Chiloquin district silviculturist, estimates that stocking has increased up to three to four times that which occurred historically. Precommercial and commercial thinning has been done, but not at a rate that keeps up with seedling recruitment. This regeneration has also come in underneath the old forest canopy. Presently there are more multi-story old ponderosa pine stands than occurred historically. The understory is predominantly ponderosa pine regeneration, but more productive sites are supporting large amounts of white fir understory. Although white fir was always a minor component of this community type, the percentages within stands, and lodgepole pine, have been increasing with fire exclusion. Fire suppression coupled with historic logging of large overstory ponderosa pine has tended to change the vegetation in some instances from predominantly ponderosa to predominantly white fir. This transition to the current mixed conifer stands occurs between 5,500 and 6,000 feet.

In the southeastern portion of the watershed the thick understory is out-competing the overstory in many areas. This results in a stressed understory and increased mortality in the old tree component. Currently the ponderosa pine type occupies a mosaic of landscape patterns, including understories left after overstory removal of large pines, regenerated clearcuts, single-story old growth and multi-storied old growth.

Current understory is decadent bitterbrush with some Idaho fescue, often 40+ years old, and other herbaceous vegetation. Bitterbrush is the primary understory component, in many cases ground cover is a needle mat between plants.

There is some discussion that there are more snags and down wood currently than in the reference period. This would be due to low mortality of the long lived (150-450 years) species, combined with a

Ponderosa Potential Vegetation



lack of frequent fires that would have kept the forest floor fairly clean. Keen has documented bark beetle epidemics that would have created locally high levels of snags every 60 to 100 years. This topic needs further investigation.

Other Types

Mixed conifer/snowbrush, Shasta red fir and white fir

The mixed conifer/snowbrush (mixed conifer/snowbrush, mixed conifer/snowbrush-manzanita and mixed conifer/snowbrush-squawcarpet), white fir (white fire/snowberry/strawberry, white fir/chinqapin-boxwood, white fir/alder/shrub meadow) and Shasta red fir (Shasta red fir/long stolon sedge, Shasta red fir/mountain hemlock, Shasta red fir -white fir/chinqapin) plant communities occupy a smaller component of the watershed (see Mixed Conifer Potential Vegetation map). Of these community types, the white fir type far exceeds the others in amount of area covered, the others being very minor components. These areas occur on the upper mid slopes where moisture regimes are higher.

The amount of fir present in the landscape is probably higher today than at any previous time. The exclusion of fire has allowed a large percentage of these community types to reach the oldest seral stages, where in the past, frequent fire would have limited mixed conifer communities to patches and stringers below 6,000 feet. The large amount of fir present in this type, and extending into the ponderosa pine type, has set the stage for high levels of insect and disease mortality and increased fire disturbance.

The amount of fragmentation in this type is lower than it was in the past, although reference to the map will show that there is no connectivity between most of the community. Snag numbers and down wood are currently high because of stress induced insect and disease mortality and the exclusion of fire, which cleans up the down woody debris. This has allowed some stands to become habitat for spotted owls and other species that were probably not here historically. Current insect activity, combined with fire risk, has made these stands transitory, and they will not remain in their current condition.

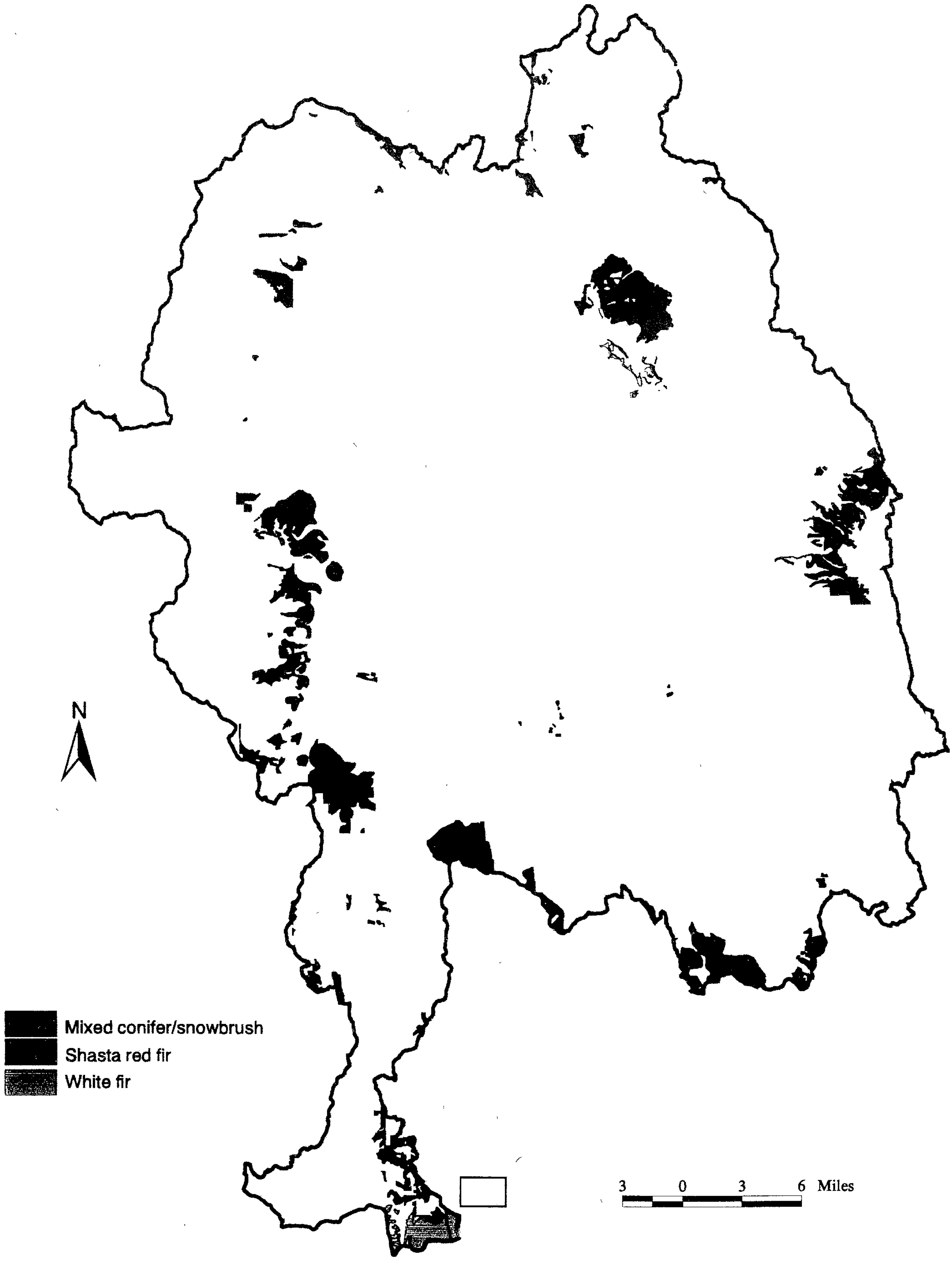
Meadow/riparian

Within the watershed, the meadow and riparian areas can be broken down into moist and dry types. Topography plays a role in this distinction, with the moist meadows and riparian stringers located where the water table will support continuous moisture. The dry meadow/riparian areas are located where water is not transported or held above ground year-round. These areas are discussed in Kovalchik's Riparian Zone Associations, and are summarized in the following section. The specific locations of these riparian zone associations have not been mapped.

Moist meadow/riparian

Klamath Marsh is part of this association and is discussed in greater detail in the water and fisheries sections. Water diversion has had the greatest effect on the current vegetation; some areas that were previously moist riparian show more dry riparian characteristics because the meadows were drained.

Mixed conifer Potential Vegetation



The moist meadow/riparian type is a varied group. Included are the lodgepole associations of lodgepole pine/bog blueberry/widefruit sedge (example location Jackie's thicket) and lodgepole pine/widefruit sedge (example Jack Creek), the white fir/queencup beadlily (found commonly across the forest), Engelmann spruce/widefruit sedge, quaking aspen-lodgepole pine/Douglas spirea/widefruit sedge, cusick bluegrass, Nebraska sedge, widefruit sedge, short-beaked sedge, slender sedge, inflated sedge, beaked sedge, and queencup beadlily.

Lodgepole pine is more of a presence, with the exclusion of fire, but because most of these associations would have only burned in late summer or drier years, the increase of lodgepole is not as significant as it is in the dry meadow/riparian associations. The primary change in this association is an increase in Kentucky bluegrass and a loss of hardwoods due to grazing pressure, and a decrease in the amount of aspen present.

Dry meadow/riparian

Because the exclusion of fire has allowed these community types to approach a later successional stage than in the reference period, lodgepole pine is presently dominating many of these sites. Riparian associations common within this watershed are lodgepole pine/bearberry (Jack Creek and Jackie's thicket), lodgepole pine/Douglas spiraea/forb (Miller Creek), lodgepole pine/bog blueberry/forb (also Jackie's thicket).

The encroachment of lodgepole onto these sites has crowded out the hardwoods and native herbs. Livestock use has also had an effect on the native vegetation. The lodgepole pine/Kentucky bluegrass community type is considered naturalized and did not exist historically. It is occupying sites where the vegetation has been altered, either by grazing, or the lowering of the water table.

Fire Ecology

In general, ponderosa pine, riparian lodgepole, and mixed conifer stands are less sustainable than during the historic era, due in part to fire exclusion. Reduced nutrient cycling, species composition changes, and stand structure changes (including fuel accumulations) associated with fire exclusion have reduced stand sustainability and resilience to disturbance. Most of the watershed has accumulated fuel hazards that support stand replacement wildfire (see Current Fire Regimes map).

Litter layers and total site nutrients have increased; however, most of the nutrients are in organic form, unavailable for plant uptake. Ponderosa pine ecosystems in the Klamath Basin evolved with frequent nutrient flushes caused by fire mineralization of organic nutrients. In the absence of fire, some organic forms may take hundreds of years to mineralize and become available for plant uptake (Kauffman, 1990). The stand density regulation provided by fire reduced competition for nutrients and water, making the nutrient "flush" even more available for the residual plants and those initiated following the fire.

Species composition changes occurring in the absence of fire have shifted some stands previously dominated by large, old ponderosa pine to stands dominated by young white fir. Other ponderosa pine stands have retained pine dominance but have displayed significant shifts in understory species

Current Fire Regimes

composition. In general, the species composition shifts have moved toward shade tolerant, fire intolerant species (or fire intolerant forms of species).

Ponderosa pine stands, with white fir in the understory or as a dominant or co-dominant species, are generally much more predisposed to stand replacement wildfire due to increased ladder fuels provided by the low-hanging limbs of the fir trees. Surface fires that would not reach ponderosa pine crowns may ignite low-hanging fir foliage. Once the lower limbs have ignited, the fire can travel up the tree with increasing intensity, generating flames that can ignite other crowns, including ponderosa pines. Once initiated, torching and crowning can often times be sustained independent of the surface fire and fuel conditions.

Bitterbrush commonly dominates the understory almost completely, causing much reduced amounts of forbs and grasses. As bitterbrush ages, dead material accumulates in the crowns of the plants. In addition to dead bitterbrush twigs and stems, ponderosa pine needle drape accumulates. This dead plant material dries out readily creating a much more flammable fuel than younger bitterbrush that is free of dead material. Flame lengths are often three to five times longer when burning decadent, needle-draped bitterbrush than when burning young, needle-free bitterbrush. The continuity, advanced age, and higher structure of bitterbrush combine to form a fuel complex that commonly elevates surface fires to the crowns of ponderosa pine.

Reference Conditions

The Historic Vegetation map shows an approximation of the dominant vegetation that would have occurred during the reference period. It was developed by overlaying the potential vegetation with historic disturbance patterns and describing the resulting vegetation. **See Appendix for historical descriptions and photos of reference conditions.**

Lodgepole Pine Types

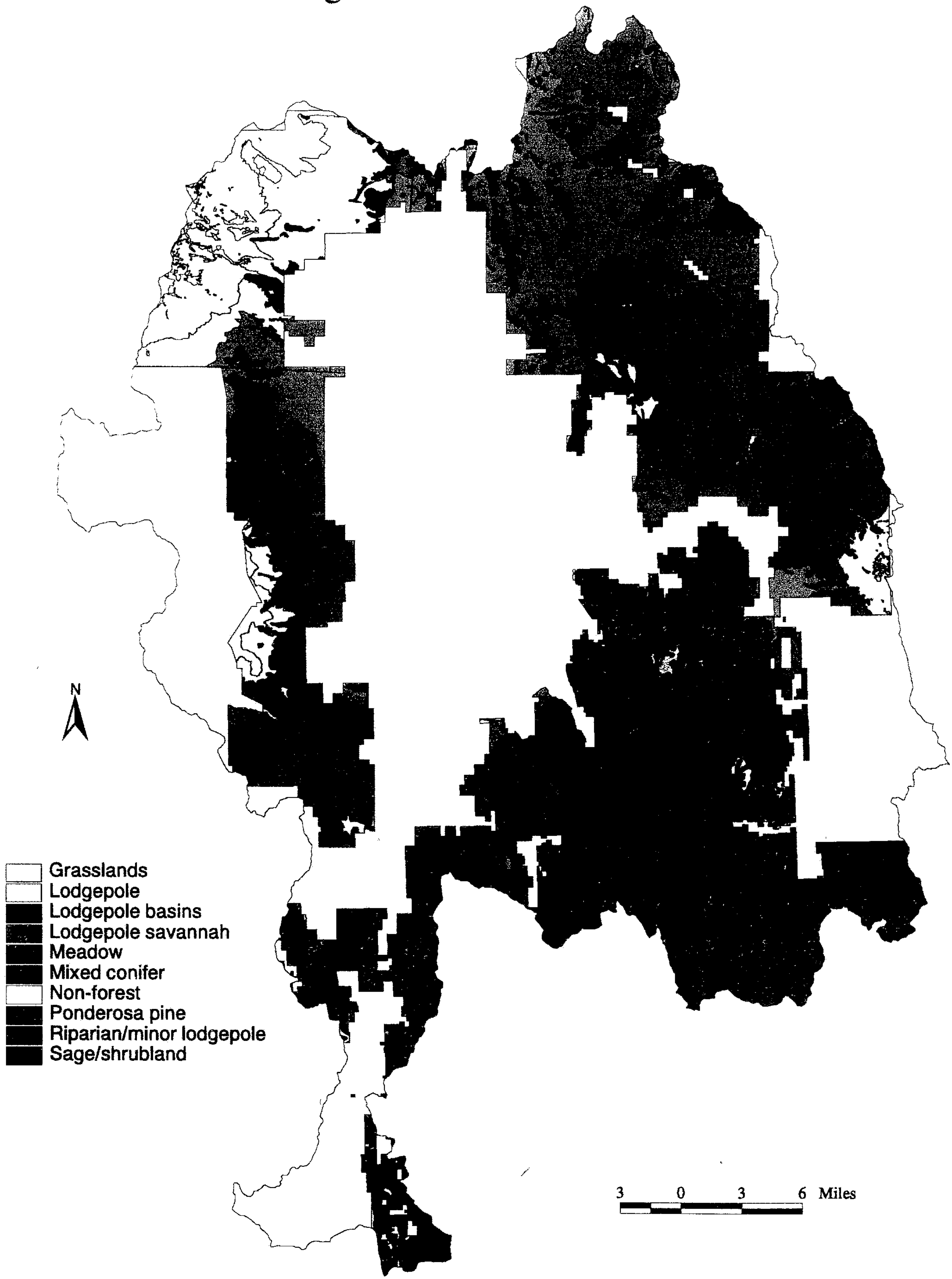
Lodgepole/manzanita

In the past these stands were probably subject to either a cycle of stand replacing fire followed by thick regeneration, followed by western pine beetle attacks resulting in an accumulation of ground fuels, and back to stand replacing fire similar to what seems to be occurring in the Park at the present time; or a cycle of frequent fires (10-35 years) which kept lodgepole from fully occupying the site and maintained an open canopy. Site specific fire data shows fire return intervals that would support the first cycle.

Lodgepole/bitterbrush

Historically, these stands were probably open savannah with scattered lodgepole, maintained by a fire return interval of less than every 35 years. Particularly in the northern part of the watershed area, there is no physical evidence of fire charred remnants of a previous stand. In fact, the lack of woody material on the ground is striking. There is photographic evidence that this is also true for the Hwy 97 corridor, which has filled in with heavy lodgepole pine stocking in the absence of fire disturbance. The stringers

Historic Vegetation



on Chiloquin district have also developed with fire exclusion. Past grazing practices and the lodgepole encroachment have worked in combination to exclude hardwoods from what were probably willow and aspen in meadow stringers along the riparian areas. There is a continuing debate of the effect of this increase of lodgepole on surface water flow and the riparian species environment where willow, aspen and black cottonwood have been displaced.

Lodgepole/needlegrass

Much the same as discussed in the lodgepole/bitterbrush communities, these areas tended towards shrub-grass and sedge dominance with historic fire disturbance. Frequent fire would have maintained the open characteristic, especially in the frost pockets, as long as sufficient fuel was available to carry fires. Because these sites are so cold, in many cases material to fuel the fires may not have been present There are anecdotal references to the presence of lodgepole stands in this area before fire suppression

Ponderosa Pine Types

Ponderosa/bitterbrush

Historically these stands had a frequent return interval (less than every 15 years) of low intensity fire. This tended to maintain old growth ponderosa pine stands in an open "park like" state, with an understory dominated by Idaho fescue and herbs, although historic photos do not show much understory vegetation in places, but rather a litter of pine needles. Younger bitterbrush plants were scattered across the landscape. Thickets of ponderosa pine regeneration, lodgepole pine and white fir were a small component of the landscape, mostly dependent on the pattern of fire. Although these old open stands occurred over a large area, a large amount of natural fragmentation in the landscape occurred with landforms and inclusion of the lodgepole pine/grass savannah, riparian areas and meadow communities now dominated by lodgepole.

Although fewer snags occurred across the landscape, dead spike tops in the larger ponderosa pine provided this habitat. These spike tops would have persisted longer than snags. Snag recruitment would have been due to localized fire flare-ups and occasional small pockets of insect mortality. In the 1920's and 1930's a bark beetle epidemic killed up to 60 percent of small localized stands.

Other Types

Mixed conifer/snowbrush, Shasta red fir and white fir

In all currently classified fir plant communities below 6,000 feet, the dominant tree species was ponderosa pine. Frequent fires in this type would have kept the stands at an earlier successional stage, except for pockets where moisture or other factors kept the fire from killing the young firs. The fire frequency along the crest (above 6,000 feet) was longer, so that more fir was present within the stands. Factors increasing the interval between fires included shorter burning seasons (due to snowpack retaining moisture longer), as well as more areas without vegetation (rock). Spotted owl habitat (multi-storied stands with high crown closure) may have existed for periods along the crest.

Little to no connectivity would have existed between the fir stands and they would have been more fragmented than currently. Because these stands were host to stand replacing type fire, the snag levels would have varied widely, depending upon the timing of the fires.

Meadow/riparian

Moist meadow/riparian

Moist meadow/riparian areas were typically a mix of hardwoods/grass/forbs, with a large willow and aspen component interspersed with open grass or sedge dominated areas. Stream banks were edged with tall willow. Aspen was found more at transition zones in the dry meadow type. Where this type occurred in wide basins, willow patches of several acres or more were present. Higher water tables and beaver dams created aquatic vegetation habitats within these types, which are much less common now.

These areas were fairly stable over time, with little variation due to fire. In the grass and sedge dominated types, fires could have burned fairly frequently in the late summer, but little change in vegetation would occur.

The lodgepole pine/bog blueberry/widefruit sedge, whitefir/queencup beadlily, Engelmann spruce/widefruit sedge and queencup beadlily association probably had a fire return interval of 100 years. The quaking aspen-lodgepole pine/Douglas spiraea/widefruit sedge type also burned infrequently. Occasional low intensity fires would rejuvenate small areas, especially edges. Fuel moisture would be too high for this type to burn with a high frequency, and when fire did enter, it would have tended to create a mosaic.

Dry meadow/riparian

During the reference period, fire burned through these areas periodically, and lodgepole pine was not present in large numbers. The vegetation remained at an earlier successional stage, with the site dominated by the associated hardwoods, brush and grasses, sedges, herbs and forbs. How this change in vegetation has affected the water table is not known.

Fire Ecology

Ponderosa pine was the dominant tree species on over 50% of the watershed during the reference era (see table next page). Small (<½ acre), even-aged stands were sprinkled across the landscape creating an uneven-aged forest. Fires burned at low levels of severity, averaging 5 to 15 years between fires (see Historic Fire Regimes map).

Lodgepole pine was present in continuous, even-aged stands, scattered throughout savannahs, and in riparian stringers. Fire was an infrequent, severe disturbance factor in the continuous stands in the northern portion of the watershed. During early stand development, these plant communities had relatively little fuel at the surface. Only after old age, or more commonly insect epidemics, did enough fuel accumulate at the surface to carry fire into the crowns. Because these stands were typically closed canopy, once fire spread into the crowns it often carried and burned large expanses at high intensity.

Historic Fire Regimes

Lodgepole savannahs and riparian stringers burned at a variety of intensities, generally killing portions of the stands (but not large expanses of near-total mortality as in the lodgepole described above). Stands dominated by mixed conifers were affected by fire similarly. Fires generally left "patchy" stands with partial mortality. Frequency was quite variable, ranging from 15 to 50 years between fires. This disturbance regime resulted in much less lodgepole pine and white fir than today.

FIRE REGIMES OF THE WILLIAMSON RIVER WATERSHED BY FOREST AND MEADOW TYPE

Fire Regime (average interval between fires)	Historic		Current	
	Forest/Range Types	Acres (% of watershed)	Forest/Range Types	Acres (% of watershed)
Frequent, low severity (5-15 years)	-Ponderosa pine, -Grasslands, -Meadow	291,966 acres (55%)	-Grasslands -Meadows -Recently harvested and burned ponderosa pine stands	16,915 acres (3%)
Variable frequency, mixed severity (15 - 50 years)	-Mixed conifer -Lodgepole savannah -Lodgepole pine (Riparian)	151,796 acres (29%)	-Partially treated conifer stands -Lodgepole pine (Riparian)	62,745 acres (12%)
Infrequent, high severity (50 - 150 years)	-Lodgepole -Lodgepole basins	82,985 acres (15%)	-Ponderosa pine -Lodgepole pine -Mixed Conifer	446,948 acres (84%)
Little Influence	-Nonforest (Rock Scabs, etc.)	5,213 acres (1%)	-Nonforest (Rock Scab, etc.)	5,309 acres (1%)

Fire regime definitions:
low severity indicates fires that kill less than 20% of the basal area at each occurrence
mixed severity indicates fires that kill 20% to 75% of the basal area at each occurrence
high severity indicates fires that kill more than 75% of the basal area at each occurrence

Note: the acres presented above do not include private ownership within the watershed.

Understory species in all but the contiguous lodgepole pine stands were much more evenly distributed amongst shrub, forb, and grass life forms. Bitterbrush was likely a prevalent shrub below 5,000 feet; however, the average height and the average age was younger.

There appears to be a direct relationship between average bitterbrush height and torching/crowning potential of overstory conifers. Lower average bitterbrush height under the historic range of variability (HRV), prevented widespread torching/crowning of the overstory.

While bitterbrush generally responds poorly to fire today, it is likely due to the average age of bitterbrush stands. Much of the bitterbrush in the Williamson basin averages more than 40 years in age Good resprouting response following fire occurs when the plants are less than 20 years of age (Simon, 1989; Havlina, 1995).

From 5,000 to 6,000 feet, snowbrush was dominant, with manzanita comprising a significant, but lesser component. Snowbrush typically resprouts following fire, while manzanita resprouting is less common.

Synthesis and Interpretation

In all lodgepole community types, lodgepole pine is at a later successional stage across the landscape than would have been maintained under a historic fire regime. Within this watershed that means that lodgepole pine is currently growing more densely and covering more area than during a historic reference period. Many of the stands at the north end of the watershed that were salvaged after the mountain pine beetle attack are still outside the historic parameters of stocking and area covered The amount of non-salvaged mortality (snags and down wood) is also higher than would have existed with frequent fire disturbance. The remaining stands of heavily mistletoe and gall rust infected lodgepole pine in the northern portion of the watershed will continue to infect the emerging understory if not treated. In addition, lodgepole has invaded riparian areas and meadows and is now occupying sites that would have historically been occupied by hardwoods. Lodgepole invasion may not have had as much influence on removal of the hardwoods as grazing and other practices, but its presence is curbing the return of the hardwood component, and contributing to continuing losses in the remainder. Riparian area protection under the interim eastside screens will tend to continue this state, unless wildfire occurs on the area.

Further analysis may show that connectivity has not changed substantially in the ponderosa pine community. There are small openings (40 acre clearcuts) that would not have been present historically. These have increased the amount of edges within the ponderosa pine type, but perhaps not significantly. The riparian grassland stringers (which are now dominated by lodgepole pine), fragmented the ponderosa community type extensively and provided extensive edges. The major change is in the amount of large ponderosa pine across the landscape.

There is currently a lack of hardwood vegetation that was present in the reference period. Prunus, willow, mountain mahogany, aspen, cottonwood and other hardwoods were scattered throughout the open ponderosa pine stands. These seem to have been crowded out by the conifers. These species have tended to reappear after fire occurrence of an intensity that removes the conifer understory.

Stand replacement fire or large scale attack by insect and disease (or a combination of both) are the high risk factors in this community type. The overstocking of the conifer layer and build up of down fuels has created conditions that lead to stand replacing fire when ignitions occur. The mortality occurring because of crowding stress is adding to the likelihood of stand replacing fire.

Changes that have occurred in the mixed conifer/snowbrush, Shasta red fir and white fir types have resulted in stands that are overstocked and stressed below 6,000 feet. These stands have gained importance as spotted owl habitat, but are in a very unstable condition. Mortality in the ponderosa pine and white fir types is occurring at present, and the likelihood of carrying these stands in their present condition for another decade is low.

Because the moist meadow/riparian areas did not develop under a frequent fire regime, the conifer vegetation may be similar to what occurred historically. However, the change in hardwood vegetation has been significant. Restoration could be accomplished by reintroducing willow and aspen.

The Eastside screens focus on providing wood in the streams by retaining conifer species in dry meadow/riparian areas. Within this watershed, riparian areas are associated with streams that were shaded by willows and hardwoods, or flowed through grass and sedge communities. In these flat systems, large wood did not play as great a role as it does in other places.

Fire Ecology

Stand structural changes due to fire exclusion include much deeper needle litter layers, greater amounts of dead and down branchwood and larger woody debris, increased stand density (more trees per acre), and a more continuous fuel bed (both horizontally and vertically). These structural changes create a fuel mosaic that increases surface fire intensity and severity, and contributes to torching and crowning fire behavior even under mild fire weather conditions

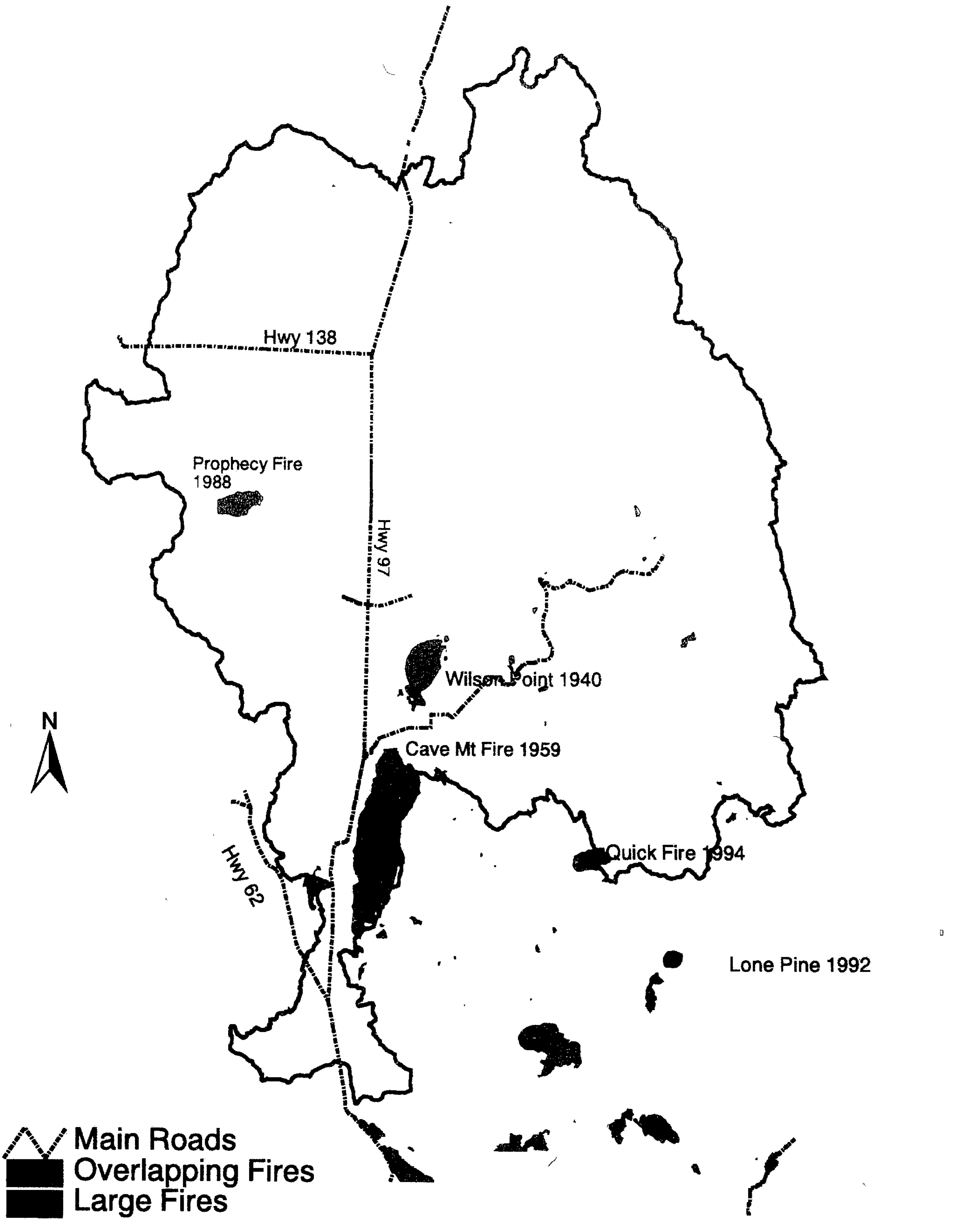
From 1912 (when forest management started on the Klamath Indian Reservation) to 1940, no significant stand replacing wildfires occurred in the Williamson River watershed. Since 1940, stand replacing wildfires have burned over 18,000 acres (see Fire History map next page) on that same area. Most of that acreage burned in the 1959 Cave Mountain Fire (14,000 acres). During the 1960's and 1970's, modern fire suppression tools (air tankers, helicopters, and well-equipped ground forces) were very successful in keeping fires small. The watershed has averaged about 45 to 50 fires per year, over 80% of which have been lightning-caused. This level of fire starts, coupled with continued fuel accumulations and associated large fires, have demonstrated that fire cannot be excluded indefinitely. The 1988 Prophecy Fire and the 1994 Quick Fire each burned over 1,000 acres in single burning periods. Even very small fires, such as the 1994 four acre Wocus fire, burned at stand replacement severity levels due to fuel accumulations beyond the historical range of variation (HRV). It is likely that this trend will continue without aggressive fuel treatments at the landscape level.

Recommendations

Riparian areas that contain dense stands of lodgepole pine can be restored to aspen/willow/cottonwood through repeated application of fire. Burn areas must be large enough to limit natural lodgepole regeneration. In addition, follow up burns should be planned to reduce lodgepole regeneration.

Management activities to restore the lodgepole areas could include pre-treatment and prescribed fire in the riparian associations. Consideration could be given to returning some of the lodgepole pine/bitterbrush type to its historic savannah appearance, depending upon management objectives for the area.

Large Fire Perimeters



Thinning stands either mechanically or by fire to provide growing space for hardwood species and grasses/sedges and forbs would increase the diversity of the ponderosa pine stands.

Management to increase the old tree component in the ponderosa pine type could be accomplished most quickly by thinning out the advanced regeneration stands and favoring ponderosa pine, whether or not a residual overstory stand is present.

Management in the mixed conifer will be dictated by the amount of risk to fire, insects and disease that management is willing to incur. The lowest risk alternative would be to return these stands to a single-story ponderosa pine type.

Restoration of fire within the Williamson River watershed should be emphasized within the ponderosa pine plant communities. Fire should be applied at intervals not exceeding every 30 to 40 years to ensure that the understory vegetation (especially bitterbrush) does not become a severe fire hazard When applying fire in ponderosa pine-bitterbrush communities, unburned islands should be left throughout the burned areas for seed sources and interim big game forage.

In general, mixed conifer communities will require mechanical treatments prior to restoring fire, due to continuous ladder fuels and densely stocked stands. However, combination treatments of thinning, followed by prescribed burning, can be very effective in reducing stand replacement wildfire hazard. In addition, these treatments would increase stand resilience to other disturbances such as insects and disease.

Lodgepole basins and high elevation lodgepole sites should be considered for prescribed fire only after large-scale mortality has caused fuel accumulations that present significant fire hazards. At that time, fire may be used to regenerate a new lodgepole stand. Hazard reduction would be recommended to avoid destruction of adjacent stands that might occur if a wildfire starts in the decadent lodgepole.

V SOILS

Issue

Portions of the watershed have been subjected to activities that may have detrimental impacts to soils.

Key Questions

1. What is the distribution and extent of soil types in the analysis area, and how are these soils affected by management activities.
2. What management activities in the analysis area are having a detrimental impact on soils.
3. To what extent has detrimental impact occurred in the analysis area.

Characterization

The geology of the study area is volcanic in parent material and landform. Low relief volcanic tablelands of the watershed area are composed primarily of Pliocene basalt and andesite flows. Steeper relief is seen in the many buttes dotting the area. These buttes, also Pliocene, were the source of the lava flows that built up the volcanic tablelands. The western portion of the area is dominated by the steep Cascade range.

The basalt and andesite rock, and associated residual soil, is buried under several feet of air-laid ash and pumice ejected from the Mazama eruption ≈7,700 years ago. Ash and pumice deposits vary from over 100 feet deep in the northern portion of the watershed, down to four feet at the south end. Ash (material <2mm in diameter) dominates the southern two-thirds of the analysis area, while the northern one-third is dominated by pumice (material >2mm in diameter). The ash and pumice deposits are the primary parent material of soil formation. Because of the relatively young age of the Mazama parent material, the soils are not well developed. Basalt and andesite rock outcrops and lacustrine sedimentary rocks are also found, but represent a small fraction of the analysis area.

Klamath Marsh is a sizeable area, but is not included in the soil analysis because of non-Forest Service jurisdiction. Because Klamath Marsh is primarily in non-Forest Service jurisdiction, the soils are not included in the Winema Soil Resource Inventory, and to date, the Natural Resource Conservation Service has no Soil Survey planned for the marsh. Parent material of the marsh is primarily ash, pumice, and diatomite although the distribution cannot be determined.

Soils in the analysis area are delineated according to soil groups. Analysis of soil group polygons and total soil group areas were derived from the 1979 Soil Resource Inventory (SRI) layer on the forest GIS. Due to land swaps and acquisitions, the calculated areas have inherent but not appreciable errors. Also, the soil group areas are calculated only for lands within the Winema National Forest boundaries, which is 59% of the total analysis area. The remaining 41% is either privately owned or administered by other government agencies, and is therefore unidentified. Soil group characteristics given below are generalities exhibited by each group, and dependant on soil types (soil types are soil groups occupying specific landforms). All soil groups and landtypes except “A”and “B” individually occupy less than 10% of the watershed analysis area. Six soil groups are of primary importance; soil groups “A”, “B”, “C”, “D” and “E”, because of their relative abundance, and soil group “G” because of its direct influence on hydrologic function.

Soil Characteristics

Parent material for the soils in the analysis area are as follows:
"A" soils - formed in deep pumice and ash deposits from Mt. Mazama
"B" soils - formed in pumice and ash over a buried residual soil
“C” soils - formed in deep material ejected from Mazama as hot, glowing avalanches
“D” soils - a fine air-laid ash, typically found on the edges of the “C” soils and in basins
“E” soils - consist of air-laid coarse sandy material ejected in the late stages of the Mazama eruption
"G" soils - formed in sediments accumulated in the valleys and low spots of the study area, generally of mixed parent material (ash, pumice, basalt, and andesite) reworked, transported, and deposited by water to form alluvial meadow soils
“H” soils - fine, air-laid ash generally with ash depths less than 40"

Activities, Soil Impacts, and Documented Constraints on Soil Resources

Several human induced activities can and do affect the soil resources. Primary activities include: timber harvest and associated management activities, livestock grazing, fire suppression, post-wildfire brush management, and road construction. Because of time constraints and the large scale of the analysis area, some activities are not quantitatively examined in detail.

Detrimental impacts on the soil resources are manifested in ways that can affect the hydrologic cycle of the Williamson River basin. A list of potential soil problems follows:

- ✓ soil compaction
- ✓ erosion (wind, sheet, and gully) and subsequent deposition
- ✓ dry ravel of exposed parent material, primarily road bank cuts
- ✓ displacement or burning of nutrient bearing A and O horizons
- ✓ disruption of nutrient cycling processes by lack of natural fire or organic input

Impact limitations are generally governed by the Winema National Forest Land and Resource Management Plan (LRMP). The LRMP generally limits compaction and displacement of the A-horizon regardless of the activity. There are also vague and non-quantitative requirements guiding soil impact with respect to water quality. Because Andisols are not fully understood (and may not be for awhile) management of soil resources should be conservative, assuming worst case scenarios, until proven otherwise.

Current Conditions

Following is a general description of soil groups found in the study area, and the percentage of area each group occupies. Percentages are only of land contained within the boundaries of the Winema National Forest. Private land, or land governed by state and other federal agencies is not included. A map of the soil group distribution is included on the next page. This map is presented as an illustration of the soil group distribution and should not be used as a planning tool.

Group "**A**" soils cover 47% of the study area and are widespread throughout. This is a direct result of the effect Mazama ash and pumice has on the area. These soils have low natural fertility, are deep enough to exclude plant roots from reaching the pre-Mazama soils, are excessively drained, have rapid infiltration rates, low detrimental compaction potential, moderate to low erosion rates (due to high infiltration rates and the gentle topography), and produce sand size sediments when eroded. Overland flow of snowmelt, or even winter rain, is very unlikely in these soils. Even runoff from naturally surfaced roads is minimal. Interception of groundwater flows by road cuts is also very rare and generally occurs only in wet spring and seep areas. Some localized overland flow is possible during intense summer storms when the dry soils have significantly lowered infiltration rates. Snowmelt, after wetting the upper soil horizons, moves rapidly through the soil profile into the water table or to the parent material interface.

Group "**B**" soils cover 21% of the study area. This soil group is found primarily on the eastern edge, and on most of the southern highlands. These soils have low natural fertility, are shallow enough to allow the deepest rooted native plants to reach the pre-Mazama soils, are excessively drained, have rapid infiltration rates, low detrimental compaction potential, low to moderate erosion rates, and produce sand size sediments when eroded. Overland flow from snowmelt or winter rains is not a frequent event in these soils, but is possible where the residual soil is relatively near the surface (20 inches or less). Some localized overland flow is possible during intense summer storms, when the dry soils have significantly lowered infiltration rates. Snowmelt, after wetting the upper soil horizon, moves rapidly through the remainder of the pumice to the residual soil interface, then along this interface to stream banks or spring locations. Some of the water will move into the residual soil and into the groundwater table. In the areas where "B" soils are shallowest, it is possible for road cuts to intercept groundwater flows along the pumice/residual soil interface. This intercepted groundwater will most likely become groundwater again after a short distance of flow in the road ditch.

Group "**C**" soils cover 6% of the study area and are found primarily, on the eastern flanks of Mt. Mazama. These soils have low natural fertility, are excessively drained, have excessive infiltration rates, low detrimental compaction potential, and low erosion rates. The Group "C" soils formed when glowing pumice flows from the Mazama eruption filled previously existing glacial valleys. Depths of the soil exceed 100 feet, putting roots out of range of water tables and pre-Mazama soils. Overland flow from snowmelt or winter rains is not a frequent event in these soils.

Distribution of Soil Groups and Landtypes

The "**D**" type soils cover 3% of the study area, primarily scattered about the west and north, situated on basins adjacent to Group "C" soils. These soils have low natural fertility, are excessively drained, have excessive infiltration rates, low detrimental compaction potential, and low erosion rates. Similar to the Group "C" soils, they formed in deep pumice deposits, making the pre-Mazama soil and water table inaccessible to roots. Overland flow from snowmelt or winter rains is uncommon in these soils.

The "**E**" type soils cover 6% of the study area, found on the north and south ends. These soils are similar to and associated with Groups "C" and "D". Group "E" soils have a finer surface texture, therefore the erosion and detrimental compaction is low to moderate.

Group "**G**"soils cover 6% of the study area, forming the meadows and valley bottoms. These soils have low to moderate natural fertility, are deep enough to exclude plant roots from reaching the pre-Mazama soils, are poorly drained, have rapid infiltration rates, moderate detrimental compaction potential, moderate potential for gully erosion, and produce sand and silt size sediments when eroded. Although these soils have high infiltration rates, their slope positions (valley bottoms) can result in maintenance of high water tables. These are locations where long term intermittent or perennial flows may occur. These soils are also likely to respond to heavy use with gullying and downcutting of existing stream channels. Overland flow is common during spring snowmelt or heavy rainfall events. Road cuts often intercept groundwater, which occasionally flows on the surface for considerable distances before returning to the groundwater system.

Group "**H**" soils cover 5% of the study area. This soil type is associated with the high elevation lands scattered throughout the south half and at the top of Fuego Mountain. These soils have moderate natural fertility, are well drained, have moderate to rapid infiltration rates, moderate to high detrimental compaction potential, low to moderate erosion rates, and produce sand and silt size sediments when eroded. Overland flow from snowmelt or winter rains is not a frequent event in these soils, but is possible where bedrock is near the surface, or is exposed in rock outcrops or in road cut banks. Some localized overland flow is possible during intense summer storms, when the dry soils have significantly lowered infiltration rates. Snowmelt, after wetting the upper soil horizon, moves rapidly through the remainder of the soil profile to the bedrock interface, then along this interface to stream banks, springs, or road cut banks. Groundwater intercepted by road cut banks will often move along the road ditch until it intercepts a stream channel.

The remaining 7% of the study area is composed of several miscellaneous soil groups, land types and soil complexes, none of which is of sufficient extent to significantly affect hydrologic function.

Soil Compaction

Soil compaction occurs whenever an object is placed on a soil mass such that the bulk density of the soil increases. Bulk density is the measure of mass that occupies a unit volume, generally stated in grams/cm^3. As the mass pushes down on the soil, voids in the soil are reduced, which potentially reduces water percolation and root movement. The LRMP (1990) was used as a guideline in determining excessive compaction, and defines detrimental compaction as when at least 20% of a unit has at least a 20% bulk density increase over undisturbed soil. Undisturbed samples generally are found in the islands of older trees that surround each site.

Because of extensive timber harvest and grazing in the past century, compaction to some degree has occurred on most of the forest. Although most of the study area has measurable compaction, very little of that compaction is showing an obvious detriment to either plant vigor or hydrologic processes. Riparian areas are an important exception. Moist soils tend to lose friction between soil particles and slide past each other when weighted. This, along with finer soil texture found in riparian soils, contributes to riparian soils being negatively affected by compaction. It must be made clear; however, that because they have been grazed for over a century, there is no area to measure a reference bulk density, making compaction on riparian soils nearly impossible to quantify. The table below lists those soils most prone to compaction.

Soils Most Susceptible to Compaction

E Group	H Group	G Group	R Group	X Group	Land Type	Soil Complexes
E1, E2, E3, E4, E5, E6, E7, E8, E10	**H1, H2, H3, H4, H5, H6,** H7	G1, G2, G3	**R8, R9, R11**	X2	**1, 2,** 3, 12, 15, 16	A2A4, 6A2, B2B4, B2H5, 2G3, A4G2, A6G2, 2G1, B8G1, B4G1, B7G1, A8G2, B3B5, 4R9

*Soils listed in "**Bold type**" are rated high to severe compaction hazard potential.*

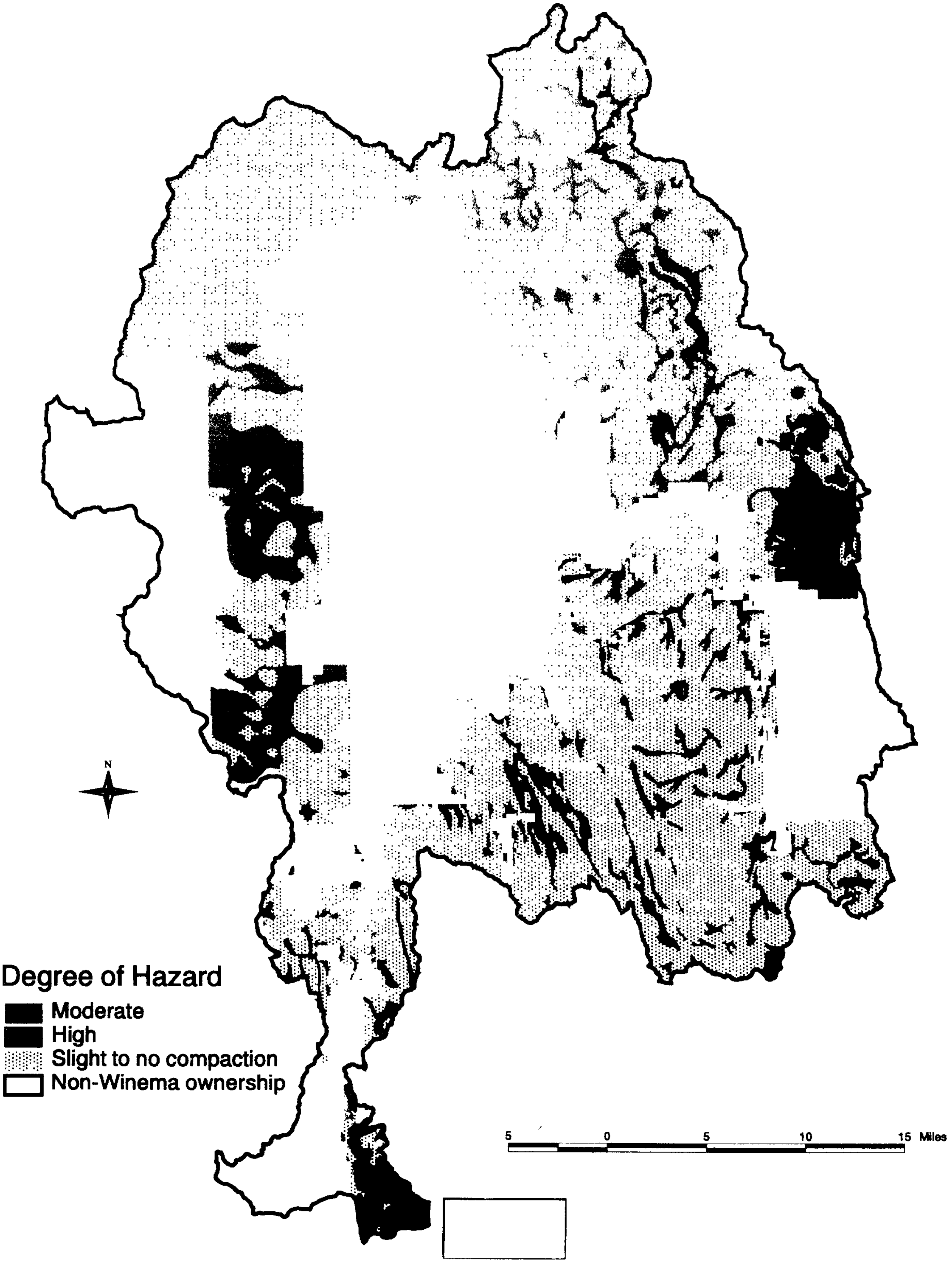
Six units were sampled, with a combined area of 402 acres. A chart summarizing sampling characteristics can be found in Appendix B. It is evident from the units sampled that the guidelines of the LRMP are not being met in all cases. However, the overall condition of the soils of the Williamson River watershed are generally improving and in functional condition. Three factors are contributing to an improving bulk density condition (mitigated compaction) on the forest:

- fewer activities involving mechanical treatment
- an increased awareness of the soils' role in forest health
- biological mixing and frost heave actions on the soil surface (although this has only a surface effect)

As an example, a recent observation on a 1996 Cave Mountain Burn mowing unit shows a 6-8 inch frost heave. Although this magnitude of frost heave is unusual (2 inches is more typical), it is evident that the physical forces of remediation are at work.

Bulk densities are showing signs of improvement. However, two types of locations exist in the analysis area where soil compaction is noticeably impacting sites; when activities are located on "H" soils, or in meadows composed of "G" soils. "H" soils generally have a fine soil texture that is prone to compaction. Although most of the soil in the analysis area with Mazama parent material tends to be coarser, with a significant gravel content, "H" soils consist mostly of fine-grained ash from the Mazama eruption. The fine-grained ash is much more prone to compaction, consequently, infiltration and tree

Detrimental Compaction Hazard of Williamson River



productivity could be greatly affected. Also, compaction has resulted in accelerated erosion on meadows ("G" type soils) that have been heavily impacted by domestic livestock and vehicle use (this is improving with better range management). Meadows are most susceptible to compaction due to the silt componente. Silt is the most compactible of the three components of texture (sand, silt, and clay) Also, "G" soils are in topographic positions that allow the soil to remain wet throughout most of the year The non "G" and "H" type soils in the analysis area are composed primarily of coarser sands and gravels. Therefore, the high water infiltration rates of the non "G" type soils are higher, and seem to be sufficient to handle storm runoff and snowmelt, even after being compacted. This holds true in all but the most extreme cases.

In short, most soils within the study area do show signs of compaction, but the extent is not considerable, and the overall detrimental effect to the analysis area is unknown at this time.

Soil Displacement, Dry Ravel, and Erosion

A much less considered soil issue, but potentially more detrimental than compaction, are activities that displace the "O" horizon (the horizon of litter accumulation and decay) and "A" horizon (the horizon of organic and mineral soil mixing). The existence of roads and mechanical operations are primary contributors to soil displacement. Guidelines are established by the LRMP for displacement:

> "Detrimental displacement is the removal of more than 50 percent of the topsoil or humus-enriched **A1** or **AC** horizons from an area of 100 square feet or more, which is at least 5 feet in width" These patches should not exceed 20 percent of a unit. The "50 percent of the topsoil or humus-enriched **A1** or **AC** horizons..." implies one-half the original depth of the **A1** and **AC** horizons should not be displaced in any fashion.

In general, this condition is improving, but activities are still occurring where excessive displacement is observed; particularly mechanical operations on soil so dry that the A horizon is lofted off site by mechanical disturbance and carried down-wind. Also, downed woody material (known as fuel to the fire folks) is a primary source of the organic material enriching the soil. This nutrient supply is immobilized until fire releases it in natural conditions. The build-up of these fuels leads to infrequent high-intensity burns, which remove far more nutrients than would be expected in frequent, lower intensity burns more natural to the analysis area. Because consumption of soil nutrients continues despite reduced input, the effect is the same as mechanically removing those soil horizons containing the nutrient-rich material.

Dry ravel is a form of displacement that is occurring in areas where roads have been cut into the natural slope, leaving a steep exposed road cut-face comprised of coarse pumice. When pumice is dry, it has little cohesion, and like a pile of sand, will unravel up-slope when the slope is at an unstable angle. As the slope unravels uphill, the pumice is dislodged and moves downslope where it is available for transportation by storm runoff. Eventually this increased sediment load could increase stream sedimentation. This situation will only worsen with the placement of new roads cut into hill slopes, and will only improve when unstable cut-banks are stabilized. The table below lists soils most prone to dry ravel.

Soils Most Susceptible to Dry Ravel

A Group	B Group	E Group	Soil Complexes
all A (on road cuts and fills), **A19** & **A14** on natural slopes	**all B** (on road cuts and fills), **B6** on natural slopes	E (on road cuts)	**A14, A19, A5B6, B4B6, B6H6** all complexes "high" on natural slopes, road cuts, and fills

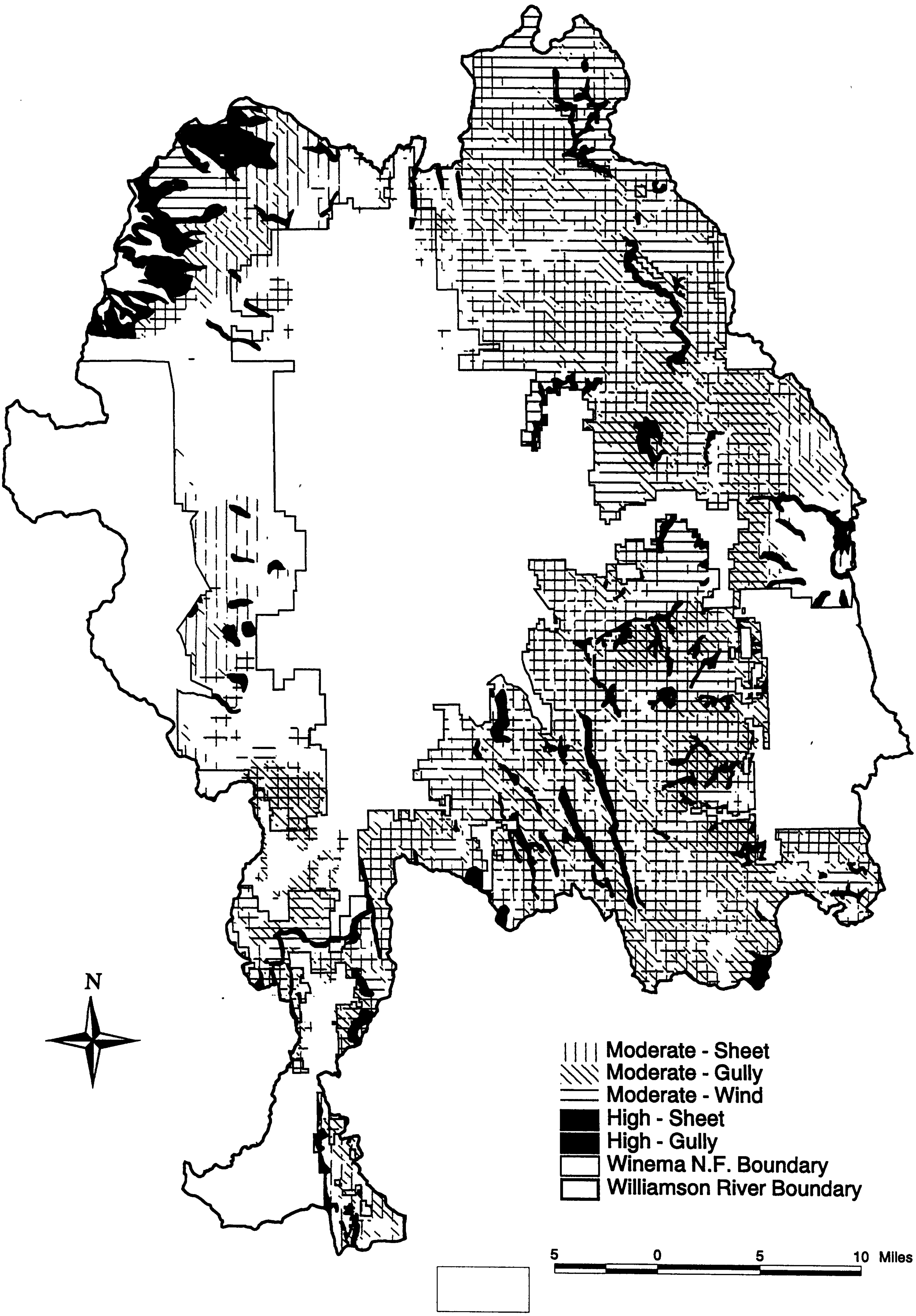
*Soils listed in " **Bold type**" are rated high to severe dry ravel potential.*

Because of high infiltration and low slope angles, displacement by erosion is generally not a big problem in the analysis area. However, isolated areas do have high potential for erosion, according to the Soil Resource Inventory. A table listing erodible soils and a map of erodible areas follows.

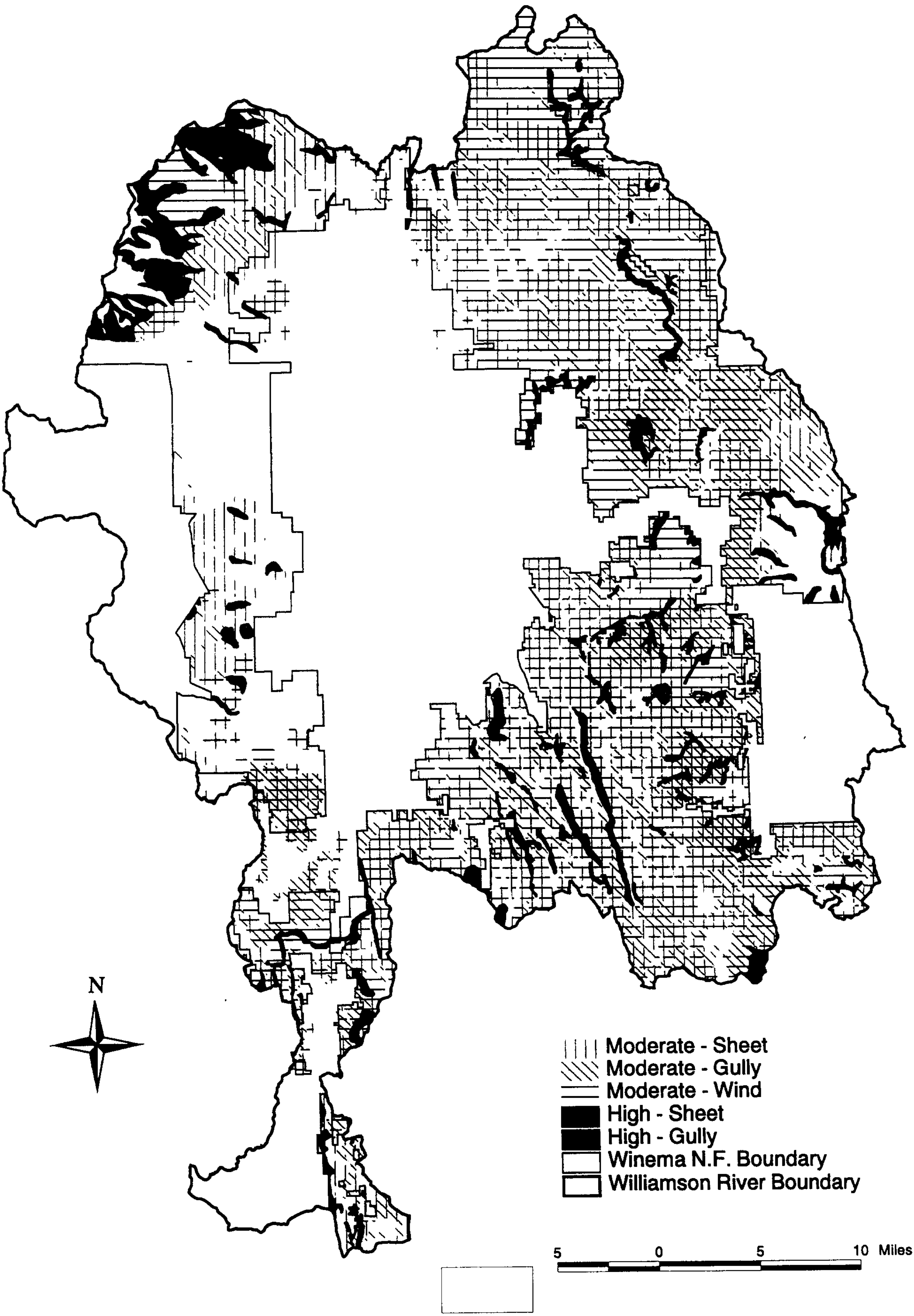
Soils and Land Types More Susceptible to Erosion Hazards

Soil & Land Types	Sheet Erosion	Gully Erosion	Wind Erosion
A Soils	A4, A5, A11, A12, **A14**, A15, A17, **A19**	A2, A3, A16	A1, 4, 5, 6, 8, 10
A complexes*	A1112, A1116, A1216, A12E4, A2A4, A2B4, A3A5, A4A6, A4A8, A4B4, A4B5, A4G2, A5A6, A5B5, A5B6, A1718	A2A4, A3A5, A4G2, A6G2, A8G1, A8G2, A8G3, A16E8, 6A2	A2A4, A3A5, A4A6, A4B4, A4B5, A4G2, A5A6, A5B5, A6A8, A6G2, A8A10, A8D1, A8G1, A8G2, A10B8, 6A8, G3
B Soils	B4, B5, **B6**, B7	B2, B3	B1, 4 ,5, 7
B complexes*	4B4, B2B4, B3B5, B4B6, B4G1, B2H5, B4G2, B4H1, B4H2, B4H5, **B4H6**, B5H2, B7B8, B7G1	B2B4, B2G1, B2H5, B3B5, B4G1, B4G2, B7G1, B8G1	B1B8, B2B4, B4G1, B4G2, B4H2, B4H5, B7G1
E Soils	E1, E4, E5, E6, **E10**	E1	
G Soils		G1, G2, G3	
G Complexes*		G2G3, 2G1, 2G2, 2G3, 6G2, 15G3, D1G2	
H Soils*	H1, **H3**, H5, **H6**	H4, H7	

Erosion Hazards of the Williamson River Basin



Erosion Hazards of the Williamson River Basin



H Complexes	H1H3, H1H4, **H5H6**	D1H4	
R Soils	R1 (20-35% slopes); **R2**, R4 (20-35% slopes); **R5**, **R7**, R8 (20-35%); **R9, R11 (30-60% slopes)**	R3,R6,R10	R4,R6,R10,R11
R Complexes	4R9		
X Soils	X2	X1, X4	
Miscellaneous Land Types	**5**, **13**, 12, 12H5, 14, 20	1, **2**, 3	6, 14, 15, 16, 19, 20, 21

*Soils listed in " **Bold type**" are rated high to severe erosion potential.*
* *Soil complexes are only listed once, under the erosion hazard that may exist within that soil complex. Example: "A8G2" is listed under the A complexes, and is not listed again under the "G Complexes".*

Reference Conditions

Although reference era soil bulk densities (measure of compaction) can be determined, the overall reference soil conditions of the analysis area are not completely understood. The primary reasons are two-fold. First, it is unclear if terms used in historical references reflect the same meaning as if they were applied today. For instance, a reference to surface mineral soil could be what we currently call the "A" horizon (the nutrient-rich horizon of mixing), or it could be describing undeveloped parent material. The difference has great implications when describing soil function. The second reason for uncertainty is the complex interaction of environmental processes that affect the chemical and physical properties of a soil. Most of these processes that contribute to soil development have been modified by forest management practices (particularly timber harvest and fire suppression). The magnitude of effect is little understood. A change from reference conditions is probable, although it is not known if the changes have a beneficial or detrimental impact.

Synthesis and Interpretation

Monitoring compaction is one of the primary methods used to determine the effects of forest management activities. If a soil is compacted, water infiltration can be compromised, root penetration limited, and water-holding capacity reduced. On the Williamson River analysis area; however, the primary soils on the Winema portion are mostly "A" and "B" soils. These soils are comprised mostly of coarse-grained soils (coarse loamy sand) with a high gravel content. The coarser the soil, the less prone it is to compaction. Of the six units extensively sampled, three were found to exceed the compaction limits set forth in the LRMP. Two of those three units were coarse-textured, and one was a fine-textured soil adjacent to a riparian area. According to the LRMP, these three units are detrimentally compacted. However, on the two coarse-textured sites, there is no evidence that the "detrimental" compaction is actually diminishing tree productivity or water infiltration. This is due to so much pore space in the coarse soil that it is difficult to compact it to the point that pore space is limited.

Of those sampled, the site most affected by mechanical operations was Merrit 23. This site was a logging operation which occurred on "H" soils. Forty-three percent of the unit area exceeded the twenty percent limit allowed for bulk density increase. Tree regeneration is stunted, and because of the degree of compaction, could very well be attributed to the increase in bulk density. The site also sits adjacent to a riparian zone, and very likely could affect water relations in the vicinity of Spring Creek. This site could be used as a model of how excessive machinery operations can negatively affect soil properties on an Andisol (volcanic soils whose particles are composed of glass). Merrit 22, an adjacent logging unit with less past machinery traffic, has the same soil properties and landscape position as Merrit 23, but fell well within the compaction limits of the LRMP. It is clear that "H" soils can support mechanical operations, but without care, can be severely compacted. All of the other sites may or may not be compacted beyond the limits of the LRMP, but they show no apparent deleterious effects. In short, all soils need to be protected from excessive compaction, but "H" soils (and all soils listed in the Susceptible to Compaction table above) need particular protection from mechanical operations.

Soil displacement has the potential of becoming the issue of most hindsight concern. Although soil displacement occurs by erosional processes, harvest activities, and fuel treatments; brush management of post stand-replacement plantations was most critically examined in the Williamson River analysis area. The reasons for close examination of brush management are:

- Brush management impacts up to seventy percent of a unit's area.
- A unit could have up to four treatments (not including thinning operations) before operations cease altogether.
- With fuel levels increasing throughout the forest and the likelihood of stand replacement fires increasing, brush management will become a more common practice in the future.

The long-term effect is not fully understood, but short term soil impacts are clearly evident. Two current brush control operations occurring in the analysis area are the Agency and Cave Mountain Burns. Both occur on low fertility pumice soils. Brush management is performed to reduce water and nutrient competition between brush and establishing plantation trees. Increased productivity is noted in these units.

The Gasline Unit #5 on Solomon Butte (Cave Mountain Burn) was examined prior to, and following a mowing operation to control brush. The operation on this unit occurred in late summer (1996) when the soil was parched. Prior to the operation, the combined depth of the "O" and "A" horizons was approximately 4"-5". After the mower completed the unit, no "O" horizon existed (except for scattered pieces of shredded vegetation) and an "A" horizon was difficult to detect. This decrease in the depth of the two horizons is due to soil displacement, and runs counter to limits defined in the LRMP. The displacement was a result of pumice soil being disturbed by both the mowing apparatus and the treads of the dozer. The fine mineral and the decomposed organic components of the soil become airborne and are blown off site.

The biggest concern arising from brush management is the potential effect on nutrient cycling in the soil. Any disruption in nutrient development has the potential of affecting long term productivity in the plantation. In the Ranch House Environmental Assessment, it is stated that competition for nutrients and water accounts for an annual mortality rate of 2-5% in pine associated stands. This figure could be greater if a nutrient base is not allowed to develop. The process of soil development, and consequently soil nutrient development, is a complex interaction of several factors; long-term affects are difficult if not impossible to predict. Some of the concerns are as follows:

- ✓ Pioneering communities, which play a role in establishing a nutrient base for later seral communities, are disrupted. Brush species such as *Ceanothus* fix atmospheric nitrogen into a mineralized form available to other higher order plant communities.
- ✓ Brush management precludes natural fire occurrence. Fire is more efficient in nutrient release than leaving the soil biological communities to decompose mowed vegetation. Conversely, a fire occurring in the brush fields on Solomon Butte would destroy the plantation. Fire; however, does volatilize a portion of the existing mineralized nutrients. It is not clear which process, fire or brush management, removes more of the on-site nutrients.
- ✓ Although the mowing operation did not compact the soil, the microbiotic community is negatively impacted. This community is responsible for nutrient cycling processes. This effect may or may not have long-term implications.

This is only a partial list used to demonstrate that the ecological process of the soil following stand-replacement and brush management is disrupted, to what extent is not fully known.

Recommendations

- ✳ Rely less on soil type polygons drawn in the SRI to predict soil types, and more on site visits by personnel familiar with soil types and potential negative affects on those types.

- ✳ Examine the impacts on Merrit #23 (and compare to Merrit #22) for productivity rates and affect on adjacent riparian areas to determine if the site would benefit from remediation efforts.

- ✳ Organize an inter-disciplinary investigation of brush management effects. Also, examine different procedures for brush management to mitigate soil impacts. Examples of different procedures could be: mowing on moist soil or snow, adjusting mower height, incorporating fire use, or mowing brush from only portions of the unit.

- ✳ Set up multi-year studies to determine rates of: organic material accumulation, erosion on analysis area soils, dry ravel, and bulk density recovery by frost heave and biological activities.

- ✳ Survey road cuts for dry ravel problem areas and attempt remediation where possible.

- ✳ During the planning process for management activities, put as much emphasis or more on soil displacement as there is on soil compaction, particularly on coarse non-cohesive soils.

VI WATER QUALITY

Issue

Water quality has been affected by increased human usage of the watershed.

Key Questions

1. Is the surface water system phosphorous or nitrogen limited?
2. Has surface water temperature in the system increased?
3. How have land management practices affected water quality?

Characterization

Human uses of water within the watershed include fish production, irrigation for crops and livestock, production of wild edible plants such as wocus, forage production for game species, and production of timber. The critical water quality parameters which provide for these uses include temperature, quantity, chemistry (especially elements that limit or increase plant production), and particulate matter including sediment and suspended solids.

Water quality parameters are highly interactive with each other, and with other factors such as land use and modification. Management practices affect water chemistry, temperature, and turbidity (sedimentation). Within the study area, grazing, pasture irrigation, forest management, logging, developed camping, and road construction and maintenance are the focuses of concern.

The highland areas, including the east flank of the Cascades, the west side of Yamsay Mountain and Booth Ridge, the major springs on the Williamson River above Klamath Marsh, and the springs in Klamath Marsh (specifically Big Springs) are characterized by 4-6°C year round groundwater, and snowmelt water during late spring runoff. The remaining lowland area of the watershed experiences late winter to early spring runoff of snowmelt. The highest water of the year in Klamath Marsh usually occurs late March through April, driven by runoff from the lowlands. Highland runoff peaks in late May to early June when runoff in the marsh is receding. The timing of these events is complicated by porous soils prevalent in the watershed. The annual high water in the lowlands creates important additional storage as it floods the lowland flood plains, wetlands and marshes. Storage of spring runoff has been negatively affected by several modern events. The ability of the watershed to store spring runoff as groundwater is very important for maintaining summer base flows.

Water temperatures in the highlands range from just above freezing during spring runoff to approximately 15°C at late summer as water enters the flat lowland area. Lowland water ranges from near freezing during spring runoff up to 25-30°C at late summer in Klamath Marsh.

The chemistry of most of the groundwater in the study area exhibits high phosphorus and low nitrogen concentrations typical of pyroclastic geologies in the Cascades. An important exception is the groundwater originating at the head of the Williamson, which is high in both elements, resulting in by far the watershed's highest biological productivity (with respect to aquatic primary production). Aquatic biological productivity of the remainder of the watershed is generally low. Since groundwater dominates this watershed, surface water of the lowland areas exhibits similar chemistry. The marshes in the basin, particularly Klamath Marsh, modify water chemistry. Instead of carrying limiting nutrients in the form of simple organic and inorganic bioavailable forms, marshes modify them into organic humic substances which lock limiting nutrients into their structure, rendering them unavailable for aquatic primary production. This is due to the present hydrology of the marshes, which give the advantage to emergent vegetation over submerged aquatic vegetation, resulting in a depletion of dissolved oxygen in the water. Oxygen promotes rapid aerobic decomposition of organic compounds into simple forms that are then available for synthesis into plants. Algae are one of the first plants to use available nutrients. This causes the green color of water where algae are in high concentrations. Brown translucent water is characteristic of humic stain and a relative lack of algae.

Current Conditions

Water quality is generally good for all uses except the most critical: fish production. The problem areas for the fishery resource include temperature, quantity, and sedimentation. Water chemistry affects aquatic flora, which in turn affect fish and other aquatic fauna.

Temperature

Summer water temperatures in the watershed generally increase with distance downstream from the water sources, which are usually springs (there are a few exceptions). In the vicinity of the Deep Creek confluence with the upper Williamson, a group of habitat parameters including water temperature begin to degrade to a condition that has a negative effect on the native rainbow/redband and introduced brook trout. According to USFS data collected during a drought cycle from 1992 to 1994, the upper Williamson River near Rocky Ford exceeded the Oregon Department of Environmental Quality (DEQ) seven day average maximum daily temperature standard of 64°F (17.8°C) from June through August. Standards were also exceeded during May 1992. Flow quantities for June through August of the drought years 1992 and 1994 were 68% and 70% of the twenty-one year average (1974-1994) respectively. In 1993, flows were 91% of the average. As expected, the 1993 temperatures are lower than either 1992 or 1994. Daily high temperatures for 1993 were usually 67-68°F, as compared to 70-73°F in 1992 and 1994. Temperatures downstream of this point and in the marsh are generally higher.

Native redband trout are assumed to be the most temperature sensitive endemic aquatic species historically present in the study area; therefore they are used here as an indicator of water and habitat quality. Redband trout monitored in the Williamson River just above Klamath Marsh during summer of 1996 remained in water where maximum daily temperatures ranged from 70-77°F continuously for over two months. These fish were still healthy and exhibited good growth and condition through this period They were observed numerous times feeding through the heat of the day. In this case the DEQ standards appear to be arbitrary, due to the trout's obvious ability to utilize this habitat. Over a long period, fish in this particular watershed have been genetically selected by their environment to withstand these conditions. Temperature tolerance gives the advantage to individuals that could then spend more time foraging and growing in what was a food rich Klamath Marsh. Thus, it is very difficult to use one set of parameters such as maximum temperature, over a regional landscape, to quantify habitat quality.

The highland streams flowing off the Cascades and Yamsay Mountain do not suffer from temperature problems, except for those segments on the valley floor. Most of these segments have been diverted for irrigation, which tends to increase surface water temperatures. The lowland stream systems are mostly intermittent or ephemeral in nature, and were, for the most part, not inhabited by trout. Any surface water in these systems naturally goes through the full range of temperature conditions as spring runoff diminishes to zero, and mean daily temperatures increase. No temperature data was found for Klamath Marsh. It is safe to assume the marsh temperatures will be at least as high as the monitoring site above the marsh. Using the presence of trout in the marsh as a temperature indicator is a flawed concept, since water chemistry (chiefly oxygen concentration) degrades to a point of uninhabitability at some point.

The trend for water temperature is likely improving due to increases in shade, and channel narrowing as a result of appropriate livestock management in riparian areas. With improving temperature profiles, and other water quality parameters (see below), the fishery resource is expected to improve in the future. However, chronically abused areas will not improve.

Quantity

Stream baseflow quantities, the low flows seen in late summer and early fall, are currently diminished by flood irrigation practices, channel incision, channelization of meadows, and potentially by hydrological effects of overstocked forests. Diminished baseflow reduces aquatic habitat volume and increases peak stream temperatures, both of which can limit aquatic life. Flood irrigation reduces flows due to increased evaporation caused by water spreading over a greater area than naturally exists in stream channels. Channel incision causes flood plains to become less accessible to the river during high water events that otherwise would store runoff water within the floodplain. Channelization of meadows has the same impact as channel incision. Impacts of increased timber density require more study to quantify potential impacts to the timing, duration and magnitude of spring runoff. It may also reduce the proportion of surface water entering the ground beneath the snowpack, which can reduce summer baseflow. Effects of high timber densities include: increased shade, thermal insulation, interception and sublimation of snow in the canopy, evapotranspiration, and decreased wind exposure. Evapotranspiration withdraws available near-surface moisture from the aquifer during the growing season, which may affect summer baseflow. Evapotranspiration may not even be one of the larger influential factors in the discussion of forest density effects on water yield. Shade from trees is very important in this watershed because of the preponderance of gentle to flat topography. The greatest effect of these factors occurs in lowland areas where the flood plains are the largest and irrigation is practiced. The influence of overstocked forests are realized across most of this watershed.

Sediment

Generally, sediment loads are naturally high throughout the basin, due to the wide distribution of pyroclastic soils. Undisturbed streams deal with sediment well by utilizing some down wood, but mostly riparian vegetation, to stabilize streambanks and sediments. Sedimentation is a serious problem on disturbed lands. Most of the disturbed land is found in the valley floor of the Williamson and in lowland meadows where channels exist. Timber harvest areas and roads also add sediments. Streambank erosion is due to combined effects of a fluctuating water table, less frequent inundation of flood plains that help maintain riparian vegetation, unregulated livestock grazing in the riparian zones, and removal of riparian hardwoods. These factors expose raw streambanks to erosion by the river. Additionally, once a sufficient volume of soil is deposited in the channel, submerged aquatic macrophytes are smothered, no longer maintaining the integrity of channel bottom soils. Timber harvest and road construction contribute to sediment loading by destabilizing soils. Sediments fill in deeper fish hiding cover and smother aquatic plants that provide cover and forage substrate. Suspended sediments shade rooted aquatic macrophytes and encourage phytoplankton production instead. Sedimentation may be slowing due to efforts such as grazing management in riparian areas and improved timber harvest practices.

Chemistry

At the Head of the River Spring on the Williamson River, the USGS (1992) has measured total phosphorus concentrations at 0.05 milligrams per liter (roughly similar to parts per million); dissolved orthophosphate at 0.04 mg/L; total Kjeldahl (organic plus inorganic) nitrogen at less than 0.20 mg/L; ammonia nitrogen at 0.02 mg/L; and dissolved nitrite plus nitrate at 0.168-0.181 mg/L, indicating the system to be somewhat nitrogen limited. Seven river miles below the head of the river is Wickiup Spring, which supplies most of the river's water volume. No water chemistry data is available from this site at this time; therefore it is assumed Wickiup Spring has water chemistry similar to the Head of the River Spring. Accompanying data from 19 river miles downstream of Head of the River Spring, at the FS road 49 crossing, indicates an approximate 97% reduction in dissolved nitrate and nitrite to <0.005-0.008 mg/L; and slightly reduced orthophosphate (12%) which indicates a very significant nitrogen limitation. Admittedly this is a small amount of data with which to speculate, but it is all we have. Nitrate and nitrite are the direct nitrogen sources for photosynthesis in most plants. These compounds are then converted to ammonia within the plants. Any additional nitrogen introduced via fertilization or metabolic wastes of livestock or humans, would further contribute to eutrophication of the system. Small increments of biological enrichment will increase existing stands of aquatic plants. Increased levels of eutrophication will clog the channel with plants, ultimately causing deficits in oxygen concentrations, which can eventually have a negative impact on aquatic fauna.

Since 97% of the available inorganic nitrogen is consumed before the 49 road crossing, this nutrient limitation could reduce aquatic macrophyte densities in much of the lower section of the river. But, since submerged aquatic and floating leafed plants are easily decomposed into simple bioavailable organic nutrients, downstream aquatic flora is common, although largely in the form of phytoplankton. A narrower historic river channel, with more overhanging banks and riparian cover, would shade and limit aquatic plant production. Thus, nutrients required to support aquatic plants would have been available further downstream. Increased suspended sediments generated by riparian damage currently shade the water in the river. This may be the primary factor in phytoplankton dominance of the lower reaches. This progression from rooted macrophytes to phytoplankton is natural, but sedimentation has moved this transition upstream from the historic range.

As long as oxygen is available in the environment, aerobic decomposition will continue to rapidly recycle nutrients important for plant production. Without oxygen, aquatic production generally decreases or ceases, in part due to a lack of nutrients. This happens when water enters modern Klamath Marsh. Vast stands of emergent vegetation in the marsh shade the water and use the nutrients. Emergent vegetation has much more carbon in its structure than submerged macrophytes or phytoplankton. Stands of emergents can be very productive and require increased amounts of oxygen to decompose the carbon structure necessary for the plants to stand above the water. The high productivity of emergent plants, along with increased requirements for oxygen to break down their structure, depletes dissolved oxygen in the marsh water. Because of this anaerobic environment, the vegetation is decomposed by the much slower anaerobic decomposition cycle. This results in the formation of various intermediate forms of organic molecules that can generally be called humic material. These compounds tie up limiting bioavailable nitrogen and phosphorus compounds, thus reducing their availability in the marsh. This further encourages emergent vegetation. The result of this in Klamath Marsh, and many of the other lowland marshes in the watershed, is the brown stain so prevalent in their waters. The lack of available nutrients limits submerged aquatic plant production, which limits forage for aquatic fauna. The resulting anaerobic environment precludes most of the native aquatic fauna. While a certain amount of this type of environment is natural, it is now much larger than would naturally occur, especially in Klamath Marsh.

Water chemistry in the highland areas is characterized as low in nitrogen and phosphorus; nitrogen remains the limiting nutrient. These streams are driven by snowmelt, and the water is surface runoff which can become shallow groundwater. It does not seem to spend enough time as groundwater to pick up appreciable concentrations of phosphorus, as does most of the spring water in the watershed; or nitrogen as in upper Williamson spring water. This chemical profile, along with low temperatures, lack of solar exposure on steeper slopes, and forested conditions prevalent in the highlands, renders these streams low in biological productivity, with excellent water quality that is highly aerated.

Reference Conditions

Temperature

Summer water temperatures in most perennial streams was lower during the reference era. The exception would be highland area water temperatures which, because of only minor disturbance, are likely nearly unchanged since the reference era. Streams were insulated from the warming effect of solar exposure by high levels of instream shade provided by riparian and aquatic vegetation; narrow, deep channel morphologies; and greater water quantities. Length and area of cool water aquatic habitat were larger due to more shading along the stream courses and higher base flows. Consequently, some portions of Klamath Marsh, where tributaries such as the Williamson, Big Springs and Sand Creek entered, were more hospitable to temperature sensitive biota well into the warm water season. Numerous smaller springs may have also contributed.

Quantity

Water flow quantities were greater during the reference era, and the timing of flows was different. Streams had good access to floodplains, storing runoff water in floodplain aquifers to be slowly released as cool spring water during the dry season. Vegetation intercepted a moderate amount of water during the growing season, since wildfire thinned timber stands, resulting in fewer overstocked stands.

A large portion of the lowland area forest was low density, large ponderosa pine. These stands provided significant shade across the flat landscape, while also allowing nighttime cooling. A thick stand of timber provides shade, but also thermally insulates the ground from nighttime cooling. The open stands likely preserved snowpack later into spring. With a delayed lowland runoff, there may occur an overlap period with the highland runoff that could combine to create maximum instantaneous runoff into Klamath Marsh. This would cause maximum flooding within the marsh, and store large quantities of groundwater over a very large area of marsh, maximizing water levels. This type of water storage increases base flow after spring runoff in the marsh.

There was more water during the warm season from late spring through summer. Evaporation from flood irrigation practices in the lowlands, less water storage in the lowland flood plains, and forest evapotranspiration now combine to reduce summer stream flows in all areas of the watershed.

Sediments

The watershed soils are mostly pumice and ash, which erodes easily, resulting in sediment prone stream channels. Despite this fact, reference era sediments were relatively stable, due to a lack of large scale ground disturbances in both the upland and riparian zones. Primarily dense stands of riparian and aquatic vegetation maintained channel stability and form in most of the streams. Large woody debris and riparian vegetation was important in the highland streams. With low levels of sediment loading, aquatic macrophytes likely ranged farther down the river, since they were not shaded and smothered by sediments. The reaches with dense aquatic macrophyte stands had clear water, which allowed light penetration for macrophyte production. Once light is sufficiently diminished, macrophytes disappear.

Chemistry

Reference era groundwater chemistry was similar to the modern profile across the watershed. Highland streams were low in limiting nutrient concentrations due to their short durations as groundwater (which tended to limit the opportunity to sorb nutrients) and the preponderance of snowmelt runoff. Concentrations of nitrogen, the apparent limiting nutrient, were likely evenly distributed throughout the river system, since shading from riparian vegetation and a narrow deep channel morphology limited aquatic plant production, making more nitrogen available for downstream primary production.

Water chemistry and ecology of Klamath Marsh was greatly influenced by the nature of its reference era tributaries, which in turn, were a reflection of the entire watershed. Hydrology played a primary role in marsh water chemistry. With Sand Creek and Big Springs supplying the west and southwest, and the Williamson River supplying the north side of the marsh with cool oxygen rich water, the marsh had large areas of aerobic habitat that maintained a eutrophic water chemistry profile rich in bioavailable forms of limiting nutrients. This produced a healthy environment for fish, especially trout. Extensive flooding of the marsh stored shallow groundwater along the margins. This water augmented the tributaries' effect. Flooding also maintained open water, which limited invasion of emergent vegetation Large areas of open water had long wind fetches which promoted aerobic conditions by virtue of the wind's ability to mix atmospheric oxygen into the water column. Natural channels efficiently drained marsh soils and maintained an aerobic condition which efficiently recycled nutrients. The net effect was a very productive and healthy marsh rich in bioavailable forms of nutrients, with a high rate of nutrient recycling due to decomposition in an aerobic environment. The open water areas especially would have been aerobic; they would be classified as a eutrophic or biologically productive environment based on energy derived from photosynthetic aquatic flora. This type of environment generally supports large communities of aquatic biota and often its waters appear as more of a greenish hue as opposed to the brown or "tea colored" water of oxygen poor dystrophic marsh waters.

Synthesis and Interpretation

Temperature

Water temperature influences distribution, speciation, seasonal habitat utilization and metabolic rates of aquatic life. A combination of low oxygen concentration and high summer water temperature have drastically reduced habitat for sensitive aquatic fauna within Klamath Marsh. The loss of streambank vegetation on the Williamson River since the turn of the century, along with segments of wider and shallower channel, have elevated temperatures above that of the river's historical channel form. The reduction of water quantity by diversion of tributaries such as Jackson, Irving, Aspen, and Deep Creeks from the river; and the river, Big Springs and Sand Creek from the marsh, has exacerbated temperature and oxygen problems. Channelization and ditching in the lowland areas and Klamath Marsh have additionally elevated temperatures via reduction of floodplain water storage.

Summer water temperatures have generally increased since the reference era. Causes include: increased solar exposure due to flood irrigation and channel widening, less summer flow quantity caused by hydrological effects of overstocked forests, evaporation from flood irrigation, reduction of effective floodplain due to ditching and channel incision, and a drastic reduction in shade caused by the relative absence of riparian hardwoods and destruction of overhanging banks. A lowered water table offers less temperature buffering capacity than a more saturated aquifer. Therefore, summer temperatures are probably higher and winter temperatures may be lower than during the reference era.

Irrigation of pasture lands in the Williamson River valley by diversions of Jackson, Irving, Aspen, and Deep Creeks, has reduced the inflow of cold water to the river during the critical summer months. The effect of these colder tributaries on temperatures in the river would be significant at the confluences of the tributaries and short distances downstream.

Grazing activities have the potential to increase water temperatures by removing streambank vegetation Actively eroding riverbanks without stabilizing vegetation are a common feature. Grazing is currently playing a substantial role in maintaining this condition. Past logging practices have also contributed to increased water temperatures by removing riparian vegetation and shade cover from stream channels.

Quantity

Water quantity during the critical warm season has been significantly reduced because of human impacts which have reduced functional storage capacity of the watershed in the form of meadows, marshes, floodplains and snowpack; and increased consumption by vegetation and evaporation. Stream diversions have reduced water quantity where streams have been channeled off their original courses through areas of highly permeable soils, which allows water to drop below the surface aquifer.

Losses due to diversion are best exemplified by the diversion of Sand Creek near highway 97. Over time, Sand Creek has created an alluvial fan, and reduced permeability of its channel by the generation of organic material and compaction of material within its stable channel. This channel efficiently delivered most of its water to the marsh during the reference era. Disturbance of this channel, or diversion across previously dry pumice flats may allow water to infiltrate below the lens that supports the shallow surface aquifer of the marsh. Distribution of water quantity during base flow conditions dictates critical habitat volume, thus population sizes of aquatic flora and fauna.

Chemistry

Water chemistry provides one of the cornerstones of biological production. Up to a certain threshold, nutrients dissolved in water increase biological productivity. Nutrients available for growth of riparian vegetation promote channel stability via the mass of vegetation produced.

Klamath Marsh has probably the most modified water chemistry of the entire watershed. Changes in ecology outlined earlier have greatly impacted water chemistry. There is likely much less oxygen and a great deal more humic material in the water since the reference era. Bioavailable forms of limiting nitrogen and phosphorus are also greatly reduced.

Developed and dispersed camp sites and water commonly go together. Most dispersed hunting and fishing camps are located on streams or next to springs, and are generally used every year. Long term use of a camping area tends to concentrate contaminants and debris that can be leached or washed into the stream. These sites have not been monitored for chemical contaminants.

Sedimentation

Sediments delivered to the streams can provide some limiting nutrients to increase biological productivity. Sediments tend to reduce habitat volume and populations of aquatics. They also can increase solar exposure and water temperature where they have filled in deeper shaded habitat. Fish eggs and aquatic plants in the stream substrate can be smothered and killed by sediments. If sediments are organic, they will reduce dissolved oxygen in the water via increased biological oxygen demand.

Sediment loads are generally higher than in the reference era as a result of factors such as streambank erosion, caused by combined effects of a fluctuating water table, inappropriate grazing in riparian zones, and removal of riparian hardwoods. These factors expose streambanks to erosion by the river. In addition to bank erosion, once a sufficient volume of soil is deposited in the channel, the aquatic macrophytes are smothered and no longer maintain the integrity of soils on the channel bottom.

Road construction and maintenance is a potential source of sediment in stream channels, although to a much lesser extent than streambank erosion. The study area contains over 1,200 miles of roads which either cross a stream, or are immediately adjacent to a channel in over 200 specific locations. Each of these locations offers the opportunity for storm runoff to wash roadbed material directly into a stream channel. Any new construction or roadbed grading makes new material susceptible to erosion. The constriction of natural channels by road crossings often accelerates erosion in the channel banks and bottoms for a short distance up and downstream. The destabilized channel also adds to the sediment load. Most of the existing roads in the study area have been in place for a considerable amount of time and have reached a state of equilibrium. The sedimentation effects associated with the initial construction have diminished to near normal. Where channels have been destabilized by road construction, the new equilibrium is somewhat greater in overall sediment production than the preconstruction sediment yields.

The vast majority of the study area has been subjected to logging activities several times since the turn of the century. Logging effects on water quality are associated with the operation of logging equipment within the riparian area, potentially increasing sediment delivery to stream channels.

Some streambank impact is present at most developed camp sites due to users of the camps trampling streambank vegetation and breaking down bank structure, but not to the point of obviously affecting water quality.

Areas of Concern

Water diversions for irrigation are necessary for forage production on cattle ranches. Irrigation can potentially modify water quality, thus irrigation return water should be monitored for quality upon re-entering the river. Land use and stream modifications can also impact water quality; potential environmental consequences of these practices warrant monitoring.

Recommendations

Increase summer baseflow by:
* reconnecting diversions where practical
* studying forest/hydrology interactions, particularly, quantifying impacts of overstocked forests on hydrologic cycles
* improving stream channel access to flood plains via a stream channel improvement program

Reduce summer high temperatures by:
* managing riparian vegetation for stream shade production and employing methods outlined to increase flow

Reduce sedimentation by:
* rehabilitating riparian vegetation on eroding banks of stream channel
* actively managing grazing in riparian zones
* repairing necessary roads and closing unnecessary roads

Improve water chemistry regime and ecology in Klamath Marsh by:
* following guidelines listed in the summer baseflow recommendations.

VII SPECIES AND HABITAT

Issue

There is a perceived reduction of fish and game species and their associated habitat.

Key Questions

1. How have important species and their habitat been affected?
2. How have threatened and endangered species been affected?

Characterization

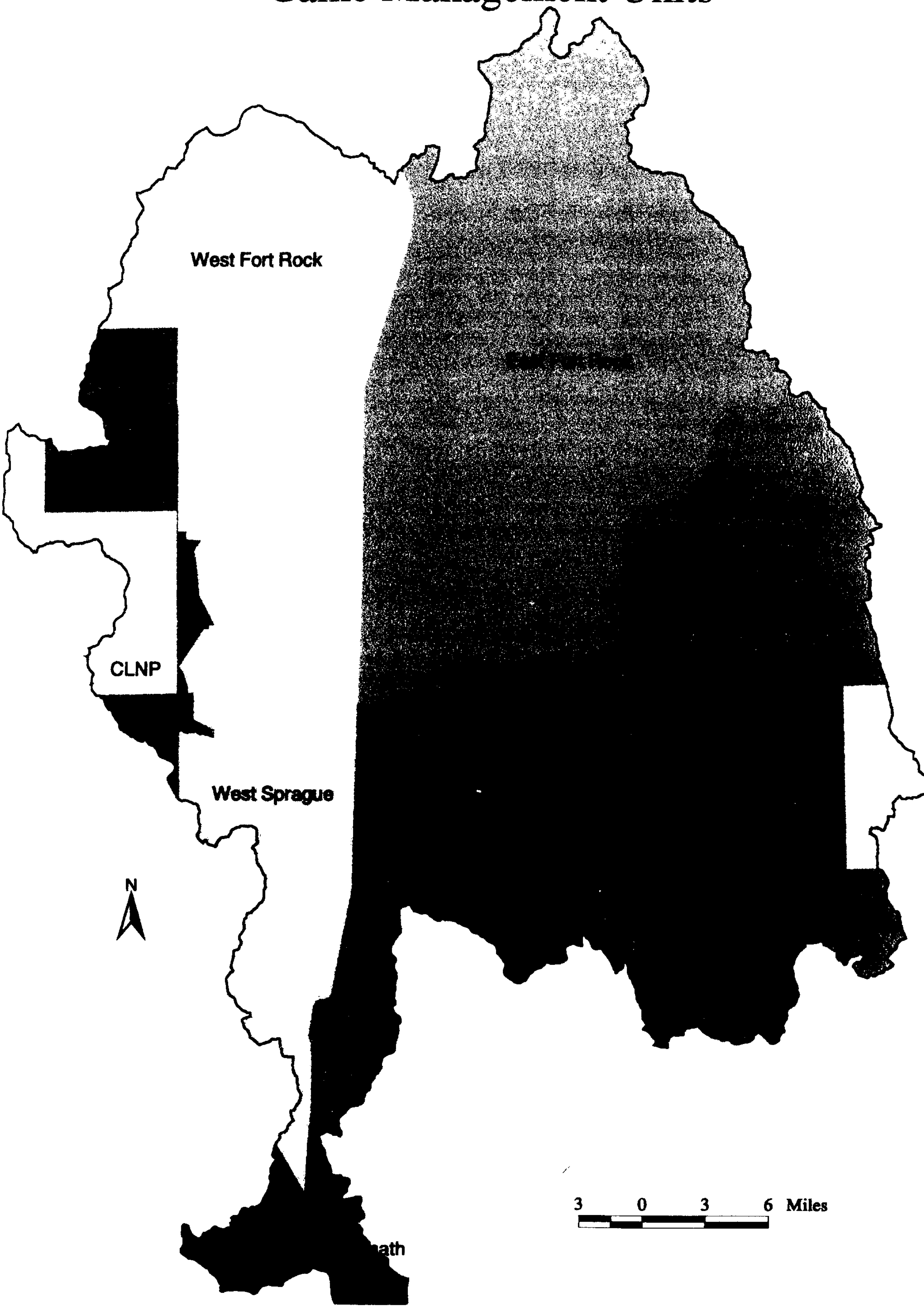
Terrestrial

Big Game

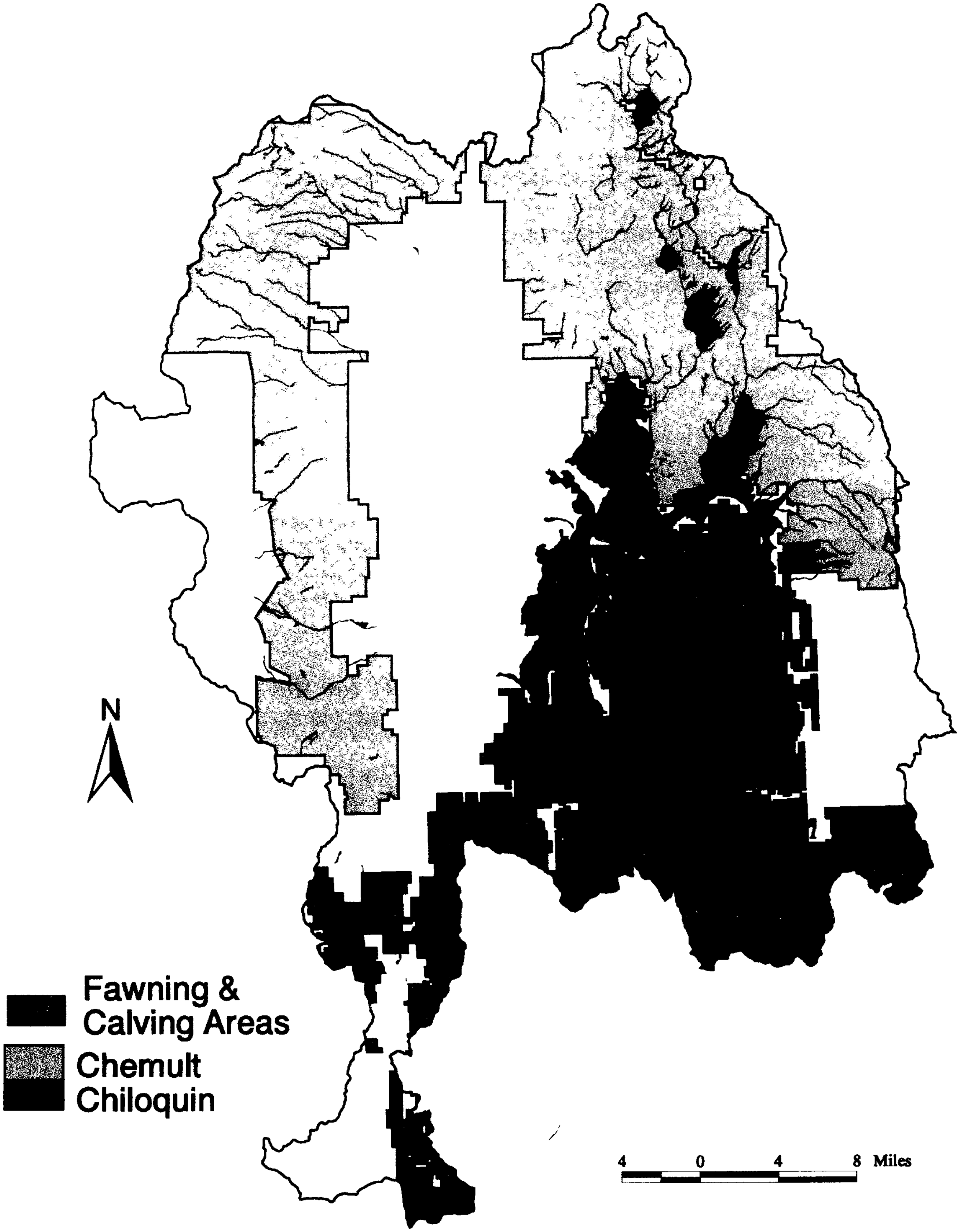
Big game species (deer, elk, and antelope) are common and distributed throughout the analysis area. Since big game is generally dependent on those habitats that provide an adequate forage base, they are generally found more in the early to mid seral habitats. Elk populations have been on the increase since the mid-1970's. Deer populations are increasing in some management units (see Game Management Units Map), and declining in others, especially on the Sprague Management Unit.

Antelope populations have increased somewhat, but do not appear to be as abundant as they were in the early 1980's. Other charts concerning big game populations and trends are located in Appendix C. There are numerous key fawning, and calving areas within the analysis area. Examples of fawning areas on the Chemult District (D1) are: Mosquito Creek Drainage, Jack Creek Drainage, Jackson Creek and adjacent private lands, and the Upper Klamath Marsh wildlife refuge. Examples of key fawning areas on the Chiloquin District (D2) include: Yoss Creek Drainage, Skellock Draw, Deep Creek, and both public and private lands on the Upper Williamson. Key calving areas on D1 include the areas listed above and Deer Creek, Cottonwood Creek, Miller Lake and Miller Creek, and Ramsay Mountain. D2 calving areas include the areas mentioned above, plus Spring Creek, the Williamson River Canyon, Hog Creek, Millhayes Meadow, and the Ray Ranch. Key antelope use areas include the migration corridor through the Upper Williamson River and Klamath Marsh, the primary use areas on both sides of US 97 including the Antelope Desert on the west side, and the area between Lenz and Mazama sidings on the east (see Fawning and Calving Areas map).

Game Management Units



Fawning and Calving Areas



Big game habitat is generally associated with riparian and timber harvest areas (see Early Seral Stage map next page). Timber harvest areas have created a transitional forage base for these species over the entire analysis area. These areas are now converting more to a cover base, and unless more major fires, or other plant community modifiers such as timber harvest, prescribed fire, and/or thinning occur, most of this transitional forage base will be replaced with conifers. The riparian plant communities, especially some of the drier meadows, are now being encroached on by conifers. Some of this encroachment is beneficial in that it provides cover adjacent to forage, but in some places the encroachment is affecting the forage base negatively by replacing desirable forbs (clover, antennaria, penstemon) with conifers.

The other factor that is affecting the overall usability of both upland and riparian habitats is the miles of roads that criss-cross the entire analysis area. These roads do provide a transitional forage base, plus access to other use areas, but the overall human use that occurs on them lowers the ability of animals to take advantage of this habitat.

Beaver - This species is not as well distributed as it was historically, due to the decline of riparian hardwood communities, but where these communities persist, beavers are fairly common (see Beaver Habitat map).

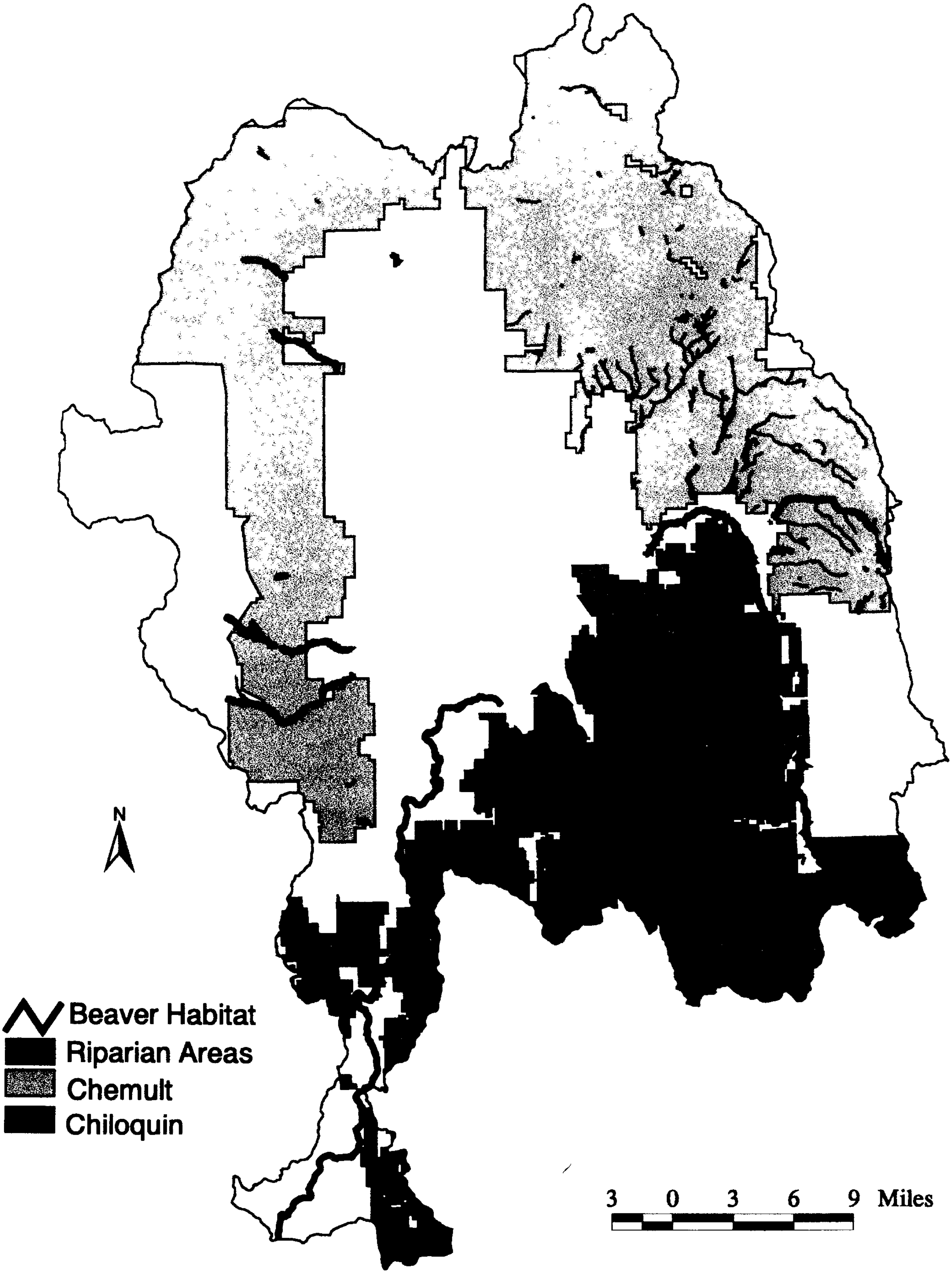
Threatened and Endangered Species (TES)

The TES species are: northern spotted owl, American peregrine falcon, bald eagle, northern goshawk (although not a TES, this species is being managed as if it were listed), greater sandhill crane, American white pelican, California wolverine, and lynx. The relative abundance is shown for those species that have been surveyed on the Chiloquin (D2) and Chemult (D1) Districts.

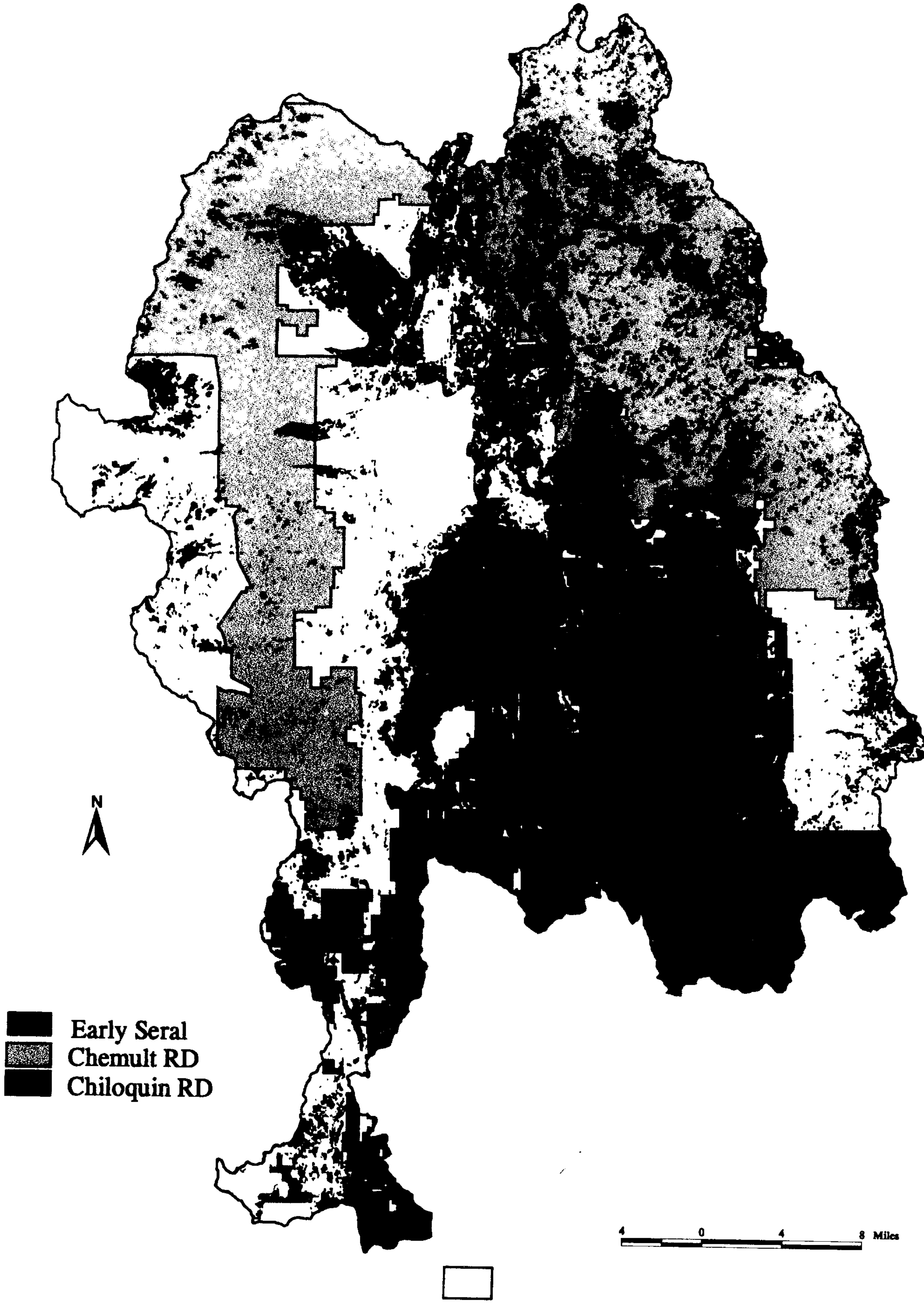
Wildlife Survey Summary for the Williamson River Basin Analysis Area

Species	Survey Years	Distribution	Abundance	District Surveyed
spotted owls	1989-1996	mixed conifer	very few	D1, D2
flammulated owls	n/a	ponderosa, mixed conifer	common	
pygmy owls	n/a	ponderosa, mixed conifer	common	D1
goshawk	1991, 1995, 1996	all plant association groups (PAG)	common on D1	D1, D2
pileated woodpecker	1991-1996	ponderosa, mixed conifer	common	D1, D2

Beaver Habitat



Early Seral Stage



Species	Survey Years	Distribution	Abundance	District Surveyed
white-headed woodpecker	1988	ponderosa, mixed conifer	few	D1, D2
marten	1989-92	lodgepole, mixed conifer	common	D1
fisher	1989-92	lodgepole, mixed conifer	very few	D1
wolverine	1989-92	mt. hemlock, mixed conifer, lodgepole	very few	D1
bald eagle	1970's to present	large conifers, marshes, lakes, streams	common	D1, D2
sandhill cranes	n/a	marshes, meadows	common	D1
mule deer	1960's to present	all PAG	common	D1, D2
great gray owl	1985, 1992, 1994	large lodgepole, ponderosa adjacent to meadows	few	D1, D2
peregrine falcon	1992	cliffs, talus slopes	none	D2
prairie falcon	1992	cliffs, talus slopes	very few	D2
bats: hoary, long-eared myotis, long-legged myotis, silver-haired, fringed, yuma, pallid	1994	large ponderosa & large mixed conifers	variable between very few to common	D1, D2
Amphibian survey-western toad	1995, 1996	marshes, lakes, wet meadows, springs, streams	common	D1, D2

Those species that are dependent on the old growth conifer communities in association with riparian habitats generally do not have as much habitat to use for nesting, perching, etc. The open-grown old growth pine forests are limited in their distribution. Old growth conifer communities are further affected by an increase in plant density, increasing the risk of major fire events that can replace these habitats. Old growth fir habitats that have moved outside of their historic ranges are at increased risk, due to past drought effects and heavier stocking levels (See Canopy Cover map). Riparian habitats, as stated above, are at risk from the various road systems that cross and/or parallel the entire length of these important communities. Other risks include conifer encroachment and loss of riparian hardwoods. It must be pointed out that some riparian hardwoods are now increasing on a small scale, due to the

Canopy Cover

overall decrease in livestock grazing on public lands. This is partially offset by continued heavy livestock use and increased developments on some private lands (see Riparian Hardwoods map).

Aquatic

The primary species of concern is the unique genetic stock of the redband form of rainbow trout that inhabit the upper Williamson River and the upper end of Klamath Marsh. Therefore most of this discussion will center on these areas. These fish fully stock the river from the Wickiup Springs area down to the Deep Creek and Aspen Creek confluence, a distance of roughly seven miles. The trout appear to use the higher quality habitat downriver of this point year-round, while only using degraded sections of the river during the cooler months. Redbands have been reported to exist downstream through Klamath Marsh. It is assumed that the redbands in the marsh are of the same stock as those in the upper Williamson. Densities of trout (including introduced brook trout) above the Deep Creek area are reported to be on the order of 2,000 fish per mile during the summer months. This density is extremely high even for a productive river. Trout densities of the high quality lower river habitat are not currently known. Summer densities in degraded habitat below the Deep Creek area are drastically reduced. From Wickiup Springs upstream to the head of the river is dammed and diverted on private land. The Forest Service has very little information on this reach. Because of the dams, little exchange of fish is thought to occur with the rest of the river. Small numbers of redbands are reported in Deep Creek up to the Ramsay Camp area, roughly 3.5 miles from the river (T31S, R11E, S21 NE/SE). No other tributaries currently have redbands in them. Jackson and Irving Creeks contain brook trout, but no redbands (See Salmonid Distribution map, next page).

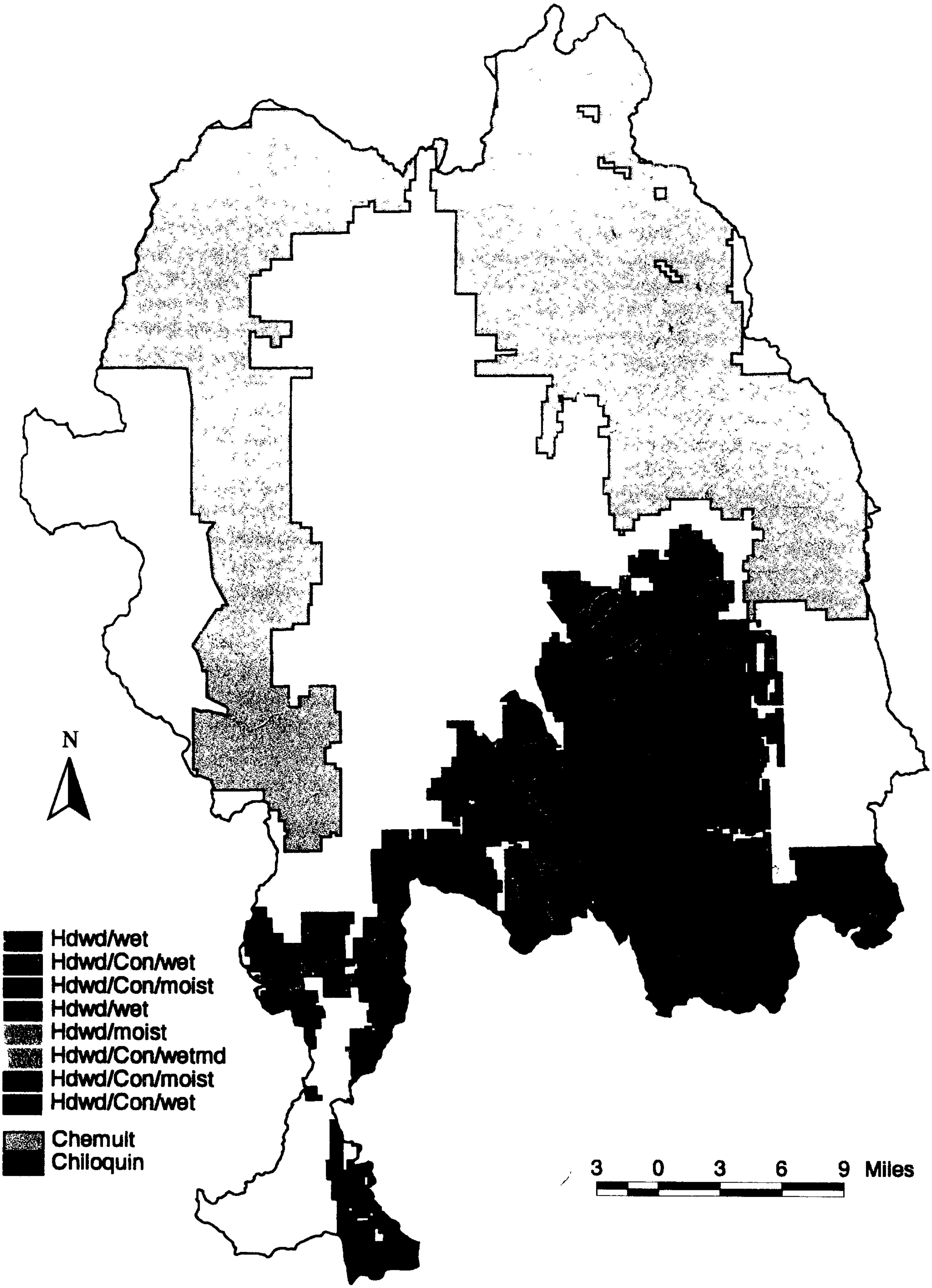
Rainbow, brown, and brook trout are exotic species that inhabit the cascade streams and Miller Lake along with kokanee salmon in the lake. Redbands may have originally inhabited these areas, but historic records are lacking. Stocking of exotics began around the turn of the century and records are sparse to nonexistent.

<u>Habitat Distribution</u>

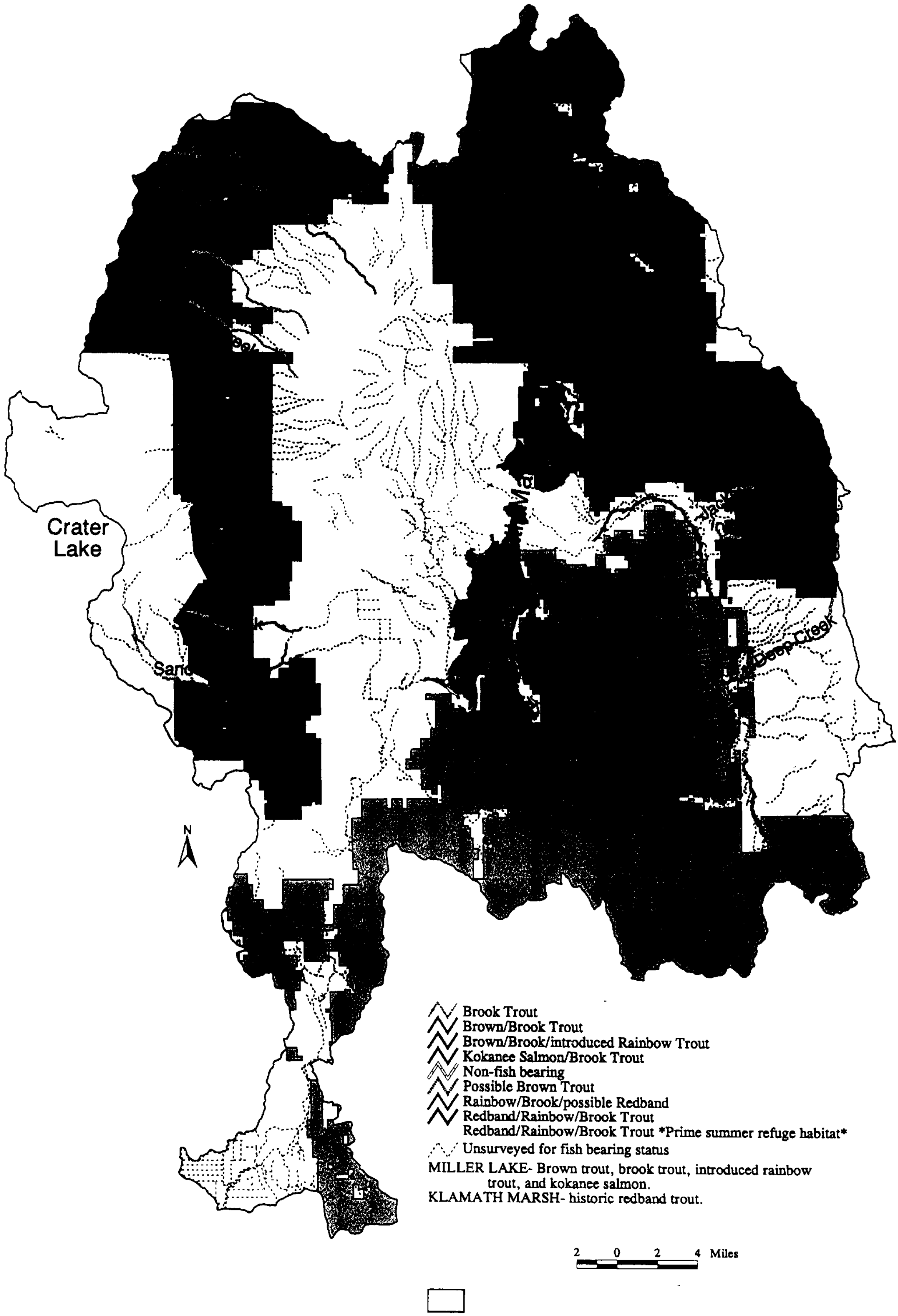
Aquatic habitat can be divided into several regions based on geology, climate, water chemistry and elevation (see Aquatic Regions map on the following page).

The **Cascades** area consists of streams in mostly glaciated valleys flowing east off the Cascades. Some of these were completely filled by pyroclastic flows from Mount Mazama, then subsequently re-carved by fluvial action. They have moderate to deep deposits of pumice and tuff, which, due to their highly absorptive nature, regulate flow and temperature throughout the year. This geology also causes very active channels with highly abrasive and unstable pyroclastic substrate such as volcanic ash. Channel forms chiefly depend on gradient and substrate size since the geology results in spring dominated water sources. Channels are typically low gradient with ash dominated substrate in lower reaches which depend on riparian vegetation for channel form. Glides and riffles are the dominate habitat types in low reaches. Upper reaches, which are generally moderate to steep, with more gravel and larger substrate, utilize abundant woody debris and riparian vegetation to form channels. They are characterized by pool riffle habitats. Existing stream survey data at this time is not comprehensive across this watershed, but with the pyroclastic soils and abundance of wood in the systems, it might be expected that pool and

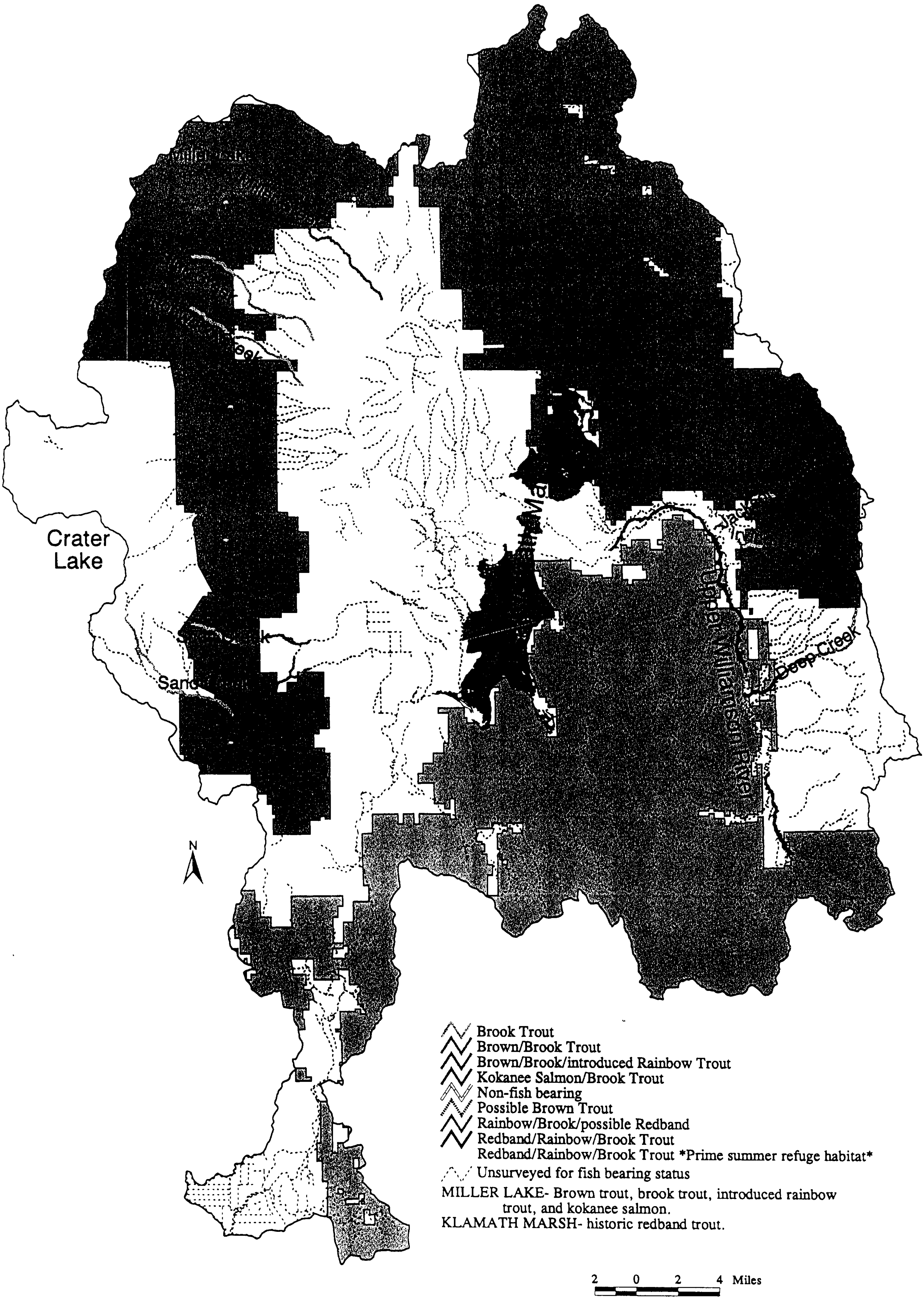
Riparian Hardwoods



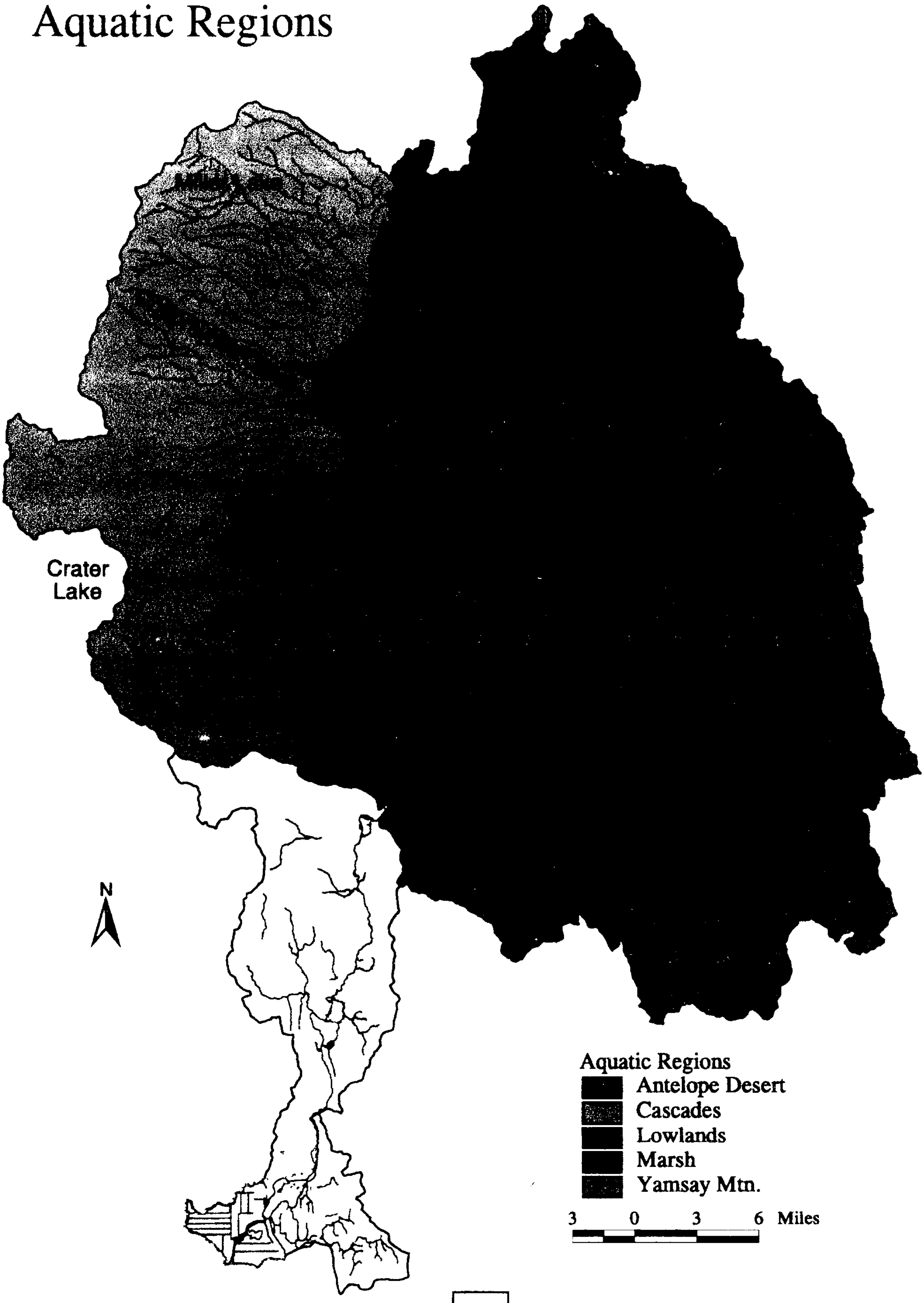
Salmonid Distribution



Salmonid Distribution



Williamson Watershed
Aquatic Regions



glide habitat is close to potential. There may be more smaller wood in the form of lodgepole in the modern era due to selective harvest of ponderosa pine since the 1800's. Shade is moderate to high due to well developed pine and mixed conifer forests. With little exception these streams are clear, cold, and low in limiting nutrient concentration. Due to these factors and the abrasiveness of the suspended pyroclastic sediments, these streams are biologically unproductive. Most of these streams never connected to Klamath Marsh during the reference era due to pre-reference era erosion of the hydraulic control on the marsh and alluvial fans deposited after the eruption of Mount Mazama.

The **Yamsay Mountain and Booth Ridge** area streams are similar to the Cascades area except they received small amounts of air laid ash from Mazama and are characterized by well defined channels carved down to parent basalt and dacite materials. Runoff remains dominated by springs. Channel gradients are moderate and shade is moderate to high. Their channels are much more stable with little abrasive sediments. This allows more benthic (substrate oriented) primary production and greater biological production than the pyroclastic substrates of the cascade streams. They exhibit low concentrations of the primary limiting nutrients: phosphorus and nitrogen. Temperature profiles are cold as well. These streams are low to moderate in their productivity. Several of these streams likely had at least seasonal aquatic connection to the Williamson during the reference era. They vary in their runoff profiles due to geological differences between each drainage, but most peak during late spring with snowmelt runoff.

The **Williamson above Klamath Marsh** is the most biologically productive stream in the watershed. Its base flow is dominated by Wickiup and Head of the River Springs, numerous small springs between these two, and Jackson Creek as it seeps into the river along the marsh formed at the creek mouth. This stream is characteristic of western spring creeks (Rosgen E and C type channels) as opposed to steeper Rosgen B type streams which are more surface water oriented. Stream gradient is very low and the substrate is mostly volcanic ash. Shade is very low due to a broad floodplain with few trees and high solar potential due to flat topography. Shade depends upon riparian and aquatic vegetation along with a deep, narrow and sinuous channel geometry. Channel and substrate stability is chiefly dependent on low stream power due to the negligible channel gradient, and the vigor of aquatic and riparian vegetation which stabilize these substrates. Woody debris in this type of channel is naturally a non-factor in channel formation and maintenance. Temperature profiles are a continuum from highland characteristics in the upper reaches dominated by large springs, to lowland characteristics as the river approaches Klamath Marsh. Biological productivity today is chiefly driven by phytoplankton (specifically diatom) production likely due to an unstable channel as well as the abrasive influence of sandy substrates. Historically, with a more stable channel, benthic plant production dominated; which is still visible in the more stable upper reaches. This is evidenced by a profusion of submerged aquatic plants and clear water.

Klamath Marsh, including Big Springs, is the most complex and easily impacted component of this watershed. Management of the marsh should consider this place as a lake, a stream and a meadow simultaneously. Subtle differences in climate, hydrology, land and water management, and ecology have dramatic results here. Timing and extent of spring runoff flows are the primary influences of the size of the marsh, the amount of stored groundwater, the extent of open water, water chemistry, temperature and biological productivity of the marsh. Gradient in the marsh is nearly zero. Shade is only provided by submerged aquatic and emergent riparian vegetation. Temperatures have the greatest amplitude here, from freezing to approximately 30°C, due to the exposed location and relative lack of groundwater influence except for Big Springs. As with large lakes, wind becomes more important here than in the streams of the watershed. There are indications that Klamath Marsh of the reference era may have been much more aquatically productive with "greener" water than its "brown" tone of today.

Lowland watersheds are somewhat of the sleeping giant of this basin. Individually they seem benign and ineffective to the basin, but because of their collective size and similar behavior, together they are a major driving force in the Klamath Marsh drainage. They provide the pulse of spring runoff water that rehydrates the marsh and defines the marsh ecology. They also store significant quantities of shallow groundwater in their own marshes and floodplains. Today they are generally much drier than during the reference era due to human intervention. Their drainages are characterized by very gentle to low relief topography. They only have a modest snowpack limited to the winter months. Shade is variable; moderate to high in forested areas, low in the meadows. This is the area where changes in shade caused by past forest practices may have a large impact on the aquatic environment of the basin. Because of the gentle topography, trees become a major source of shade. Changes in levels of shade from the reference era can dramatically effect snowmelt and runoff timing and duration. In turn, Klamath Marsh is the direct recipient of any change. These streams provide very limited aquatic habitat due to their seasonal nature, low levels of limiting nutrients, and forest shading.

Threatened and Endangered Species (TES)

Bull Trout - No credible reports of bull trout observation were found for the analysis area. Since bull trout exist in the Big and Little Deschutes, Sycan, Sprague and Klamath Lake drainages, it is highly likely they did exist at one time in the Klamath Marsh drainage. Mount Mazama was most likely the primary factor in bull trout eradication from the analysis area. All of the streams draining to Klamath Marsh were impacted by the eruption of the mountain. Bull trout currently inhabit Sun Creek on the southeast flank of the mountain, but this stock would also have been eliminated by the eruption. Sun Creek was most likely recolonized from other Klamath Lake stocks that were not directly impacted by the eruption. Two locations that might have been possible refugia for bull trout during the eruptive phase of Mount Mazama are Miller Lake and the upper Williamson.

Species such as tui chub and the Miller Lake lamprey survived in Miller Lake. If bull trout were present they may have survived in the lake itself, but the most likely spawning habitat in Evening Creek is now too small for spawning habitat suitable for bull trout of the size that Miller Lake could produce. Without suitable spawning habitat, any remaining bull trout would have been the last generation to inhabit the lake. It is possible that some fish survived in Miller and Howlock Creeks below the lake, but no records were found of bull trout or redbands before the introduction of exotic stocks of rainbow and brown trout early in the twentieth century.

Bull trout may have survived temporarily in the upper Williamson in refuge habitat provided by the groundwater sources at the Head of the River and Wickiup Springs. Jackson Creek would have been the most likely spawning habitat considering its size, low temperatures and suitable spawning gravel. Air laid ash from Mount Mazama would have choked the interstices of the gravel rendering it useless for spawning. Even with some suitable spawning gravel remaining, the ash washed out of the Jackson Creek drainage eventually created a delta that has since cut off the direct aquatic connection to the Williamson River during fall, when bull trout traditionally enter tributaries to spawn. There is a remote possibility bull trout survived as a headwater stock in Jackson Creek, but none were reported when the creek was first stocked with brook trout during the 1930's. Competition with brook trout in this low productivity stream would have been difficult at best and most likely would have resulted in extinction of bull trout in this stream. Today there are several isolated streams originating on the east slope of the Cascade Mountains, as well as Jackson Creek, that are suitable habitat for reintroduction of bull trout Detailed suitability analysis is beyond the scope of this project

Miller Lake Lamprey - Very little is currently known. Darryl Gowan (USFS, Fishery Biologist, personal communication) collected one adult lamprey from Deep Creek. A Crew from Oregon State University (OSU) also collected several ammocoetes and one adult at Rocky Ford. Adults are required for positive ID. Dr. Doug Markel at OSU inspected the sample from Rocky Ford and indicated it looked very much like a Miller Lake lamprey, but he needs more adult samples to be confident. Prior to collecting these specimens the Miller Lake lamprey was only known to inhabit Miller Lake. If this lamprey is the same species, then these are the only adults sampled since ODFW eradicated the lamprey from Miller Lake in 1958 (Roger Smith, ODFW, personal communication). Since they are thought to be extinct, very little is known of their life history and range. Dr. Markel indicated that Miller Lake lamprey are the smallest parasitic lamprey known. The OSU crew that sampled the adult from Rocky Ford also found three inch long dace with parasitic lamprey scars on them. This is further evidence of the possible existence of Miller Lake lamprey. The USFWS is planning on further sampling to determine the lamprey species found in Miller Creek,

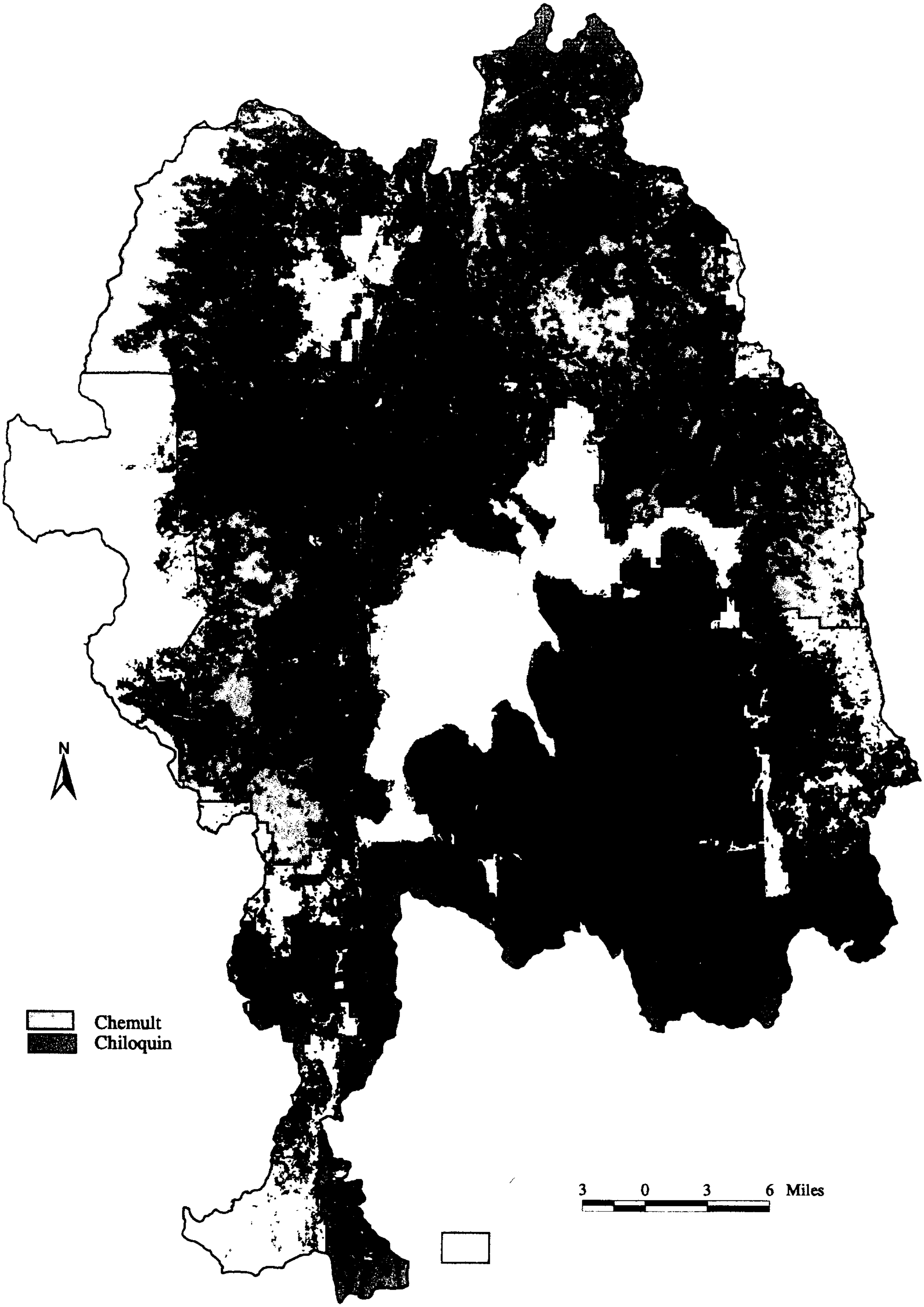
Current Conditions

Terrestrial

Big Game - The transitional forage base that was created by timber harvest activities in the late 1970's thru the mid-1980's is now changing to a cover base, thereby eliminating some of the early seral grasses, sedges, and forbs. The meadows that were once dominated by early to mid-seral forage, are now moving toward a climax state. This state is much different in some meadows than was historical development, due to the dominance of Kentucky bluegrass and the general drying out of meadow communities due to livestock grazing, road system effects, and several years of drought.

The dominant upland forage shrub is bitterbrush (see Bitterbrush Forage map). This species continues to provide mid-summer through fall forage for big game. However, in some cases it is becoming more of a cover species than a forage species due to its maturity, as the forage value is reduced by more nutrients being locked into the stems and trunks, and the plant developing to a height where new leader growth is either unavailable or does not occur.

Bitterbrush Forage



Long range trends for big game populations will be to decline as the forage base changes to a cover base, barring any major fire events that will rejuvenate the forage base. Currently, elk populations are increasing and will continue to until their populations reach the habitat carrying capacity. No predictive models have been run to determine when this will occur, but with the current movement of transitional forage toward a cover base, it could happen within the next five to ten years. The same scenario will affect both deer and antelope, probably more so, since they are not quite as dominant in nature as elk.

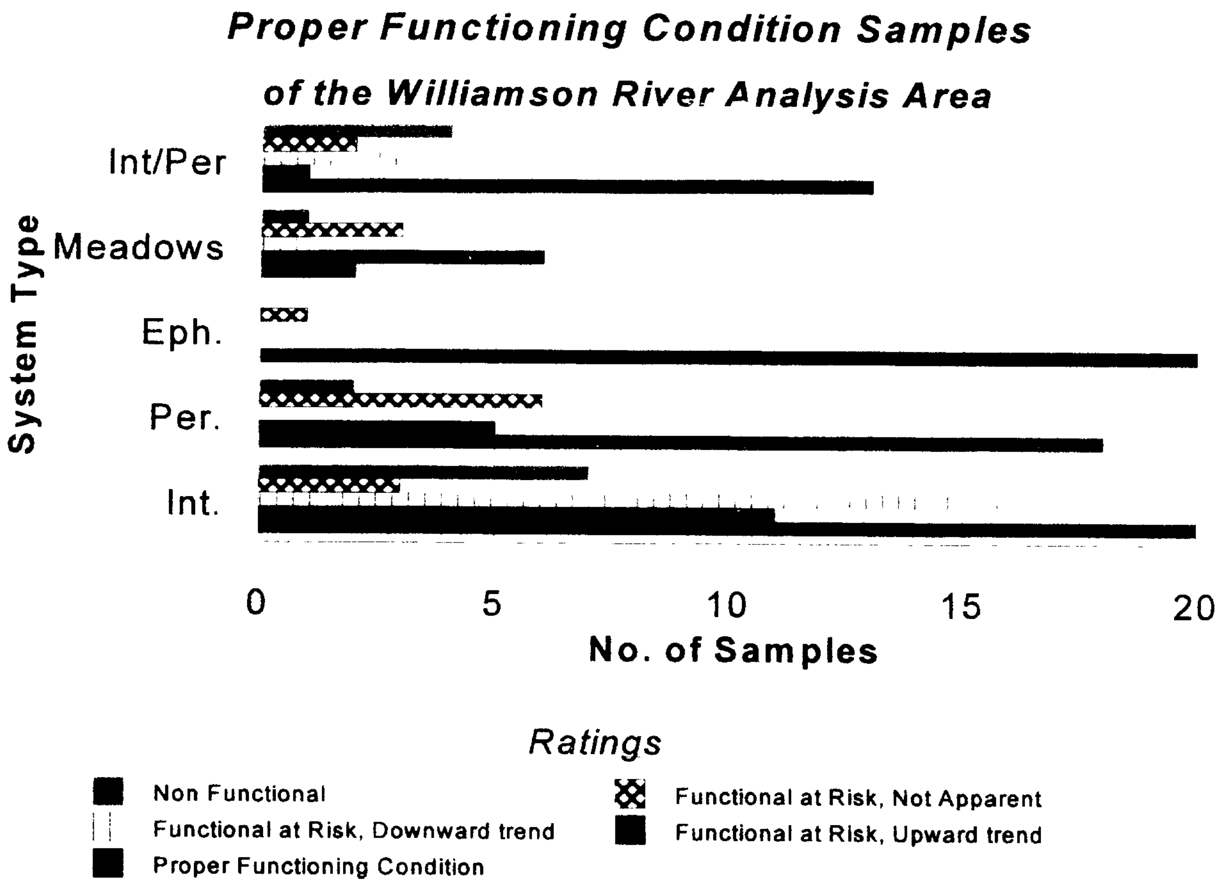
Old Growth Conifer Habitat - It is expected that the current old growth areas will remain static until other stands develop and become old growth over the next 20 to 100 years, depending on tree species and present age of the individual stands. This transition is subject to major fire occurrences, insects and disease epidemics, and/or management that allows trees to grow larger, such as thinning from below, sanitation harvests, and prescribed burning. The trend for old growth dependent wildlife is expected to remain static or decline, depending on the above conditions.

Old Growth Ponderosa Pine Habitat - This habitat type is becoming increasingly threatened from overstocking, the result of 70+ years of active fire suppression. The primary areas of old growth ponderosa pine are located along the mid-slope portion of the panhandle west of Hwy 97, the mid to upper slopes of Yamsay Mountain, and the Wildhorse ridge area on Chiloquin District. There are other smaller areas of old growth ponderosa pine scattered across both districts that have been set aside primarily as eagle habitat and/or old growth areas. Examples of wildlife species also dependent on this habitat include Yuma myotis, hoary bat, pygmy nuthatch, flammulated owl, white-headed woodpecker and Williamson's sapsucker.

Old Growth Mixed Conifer Habitat - This habitat type (at least the mixed conifer component), due to active fire suppression and selective logging practices, has expanded its range from small isolated 5 acre or less pockets on the north slopes and tops of the more dominant buttes and mountains (Applegate Butte, Yamsay Mountain), to pockets of 20 acres or more, occurring further downslope. These areas, like the ponderosa pine, are increasingly at risk from insects, disease, and potential wildfire conflagrations. Examples of important wildlife species dependent on this habitat type include the northern spotted owl, marten, fisher, California wolverine, pileated woodpecker and northern goshawk.

Old Growth Lodgepole Pine Habitat - This habitat type has been reduced significantly due to the pine bark beetle outbreaks of the late 1970's and early to mid-1980's. Forest Service and adjacent timberland owners moved fairly quickly to eliminate the infestations by harvesting large blocks of the affected conifers. Harvesting occurred across the NE portion of Chemult District and in large areas of privately owned timberlands on both sides of Hwy 97. Only scattered small set-aside areas for northern goshawks and black backed woodpeckers remained untreated. These blocks were generally 75 acres in size. Examples of other important wildlife that use this habitat include great gray owls, fishers, martens, eagles, western gray squirrel and pygmy nuthatch.

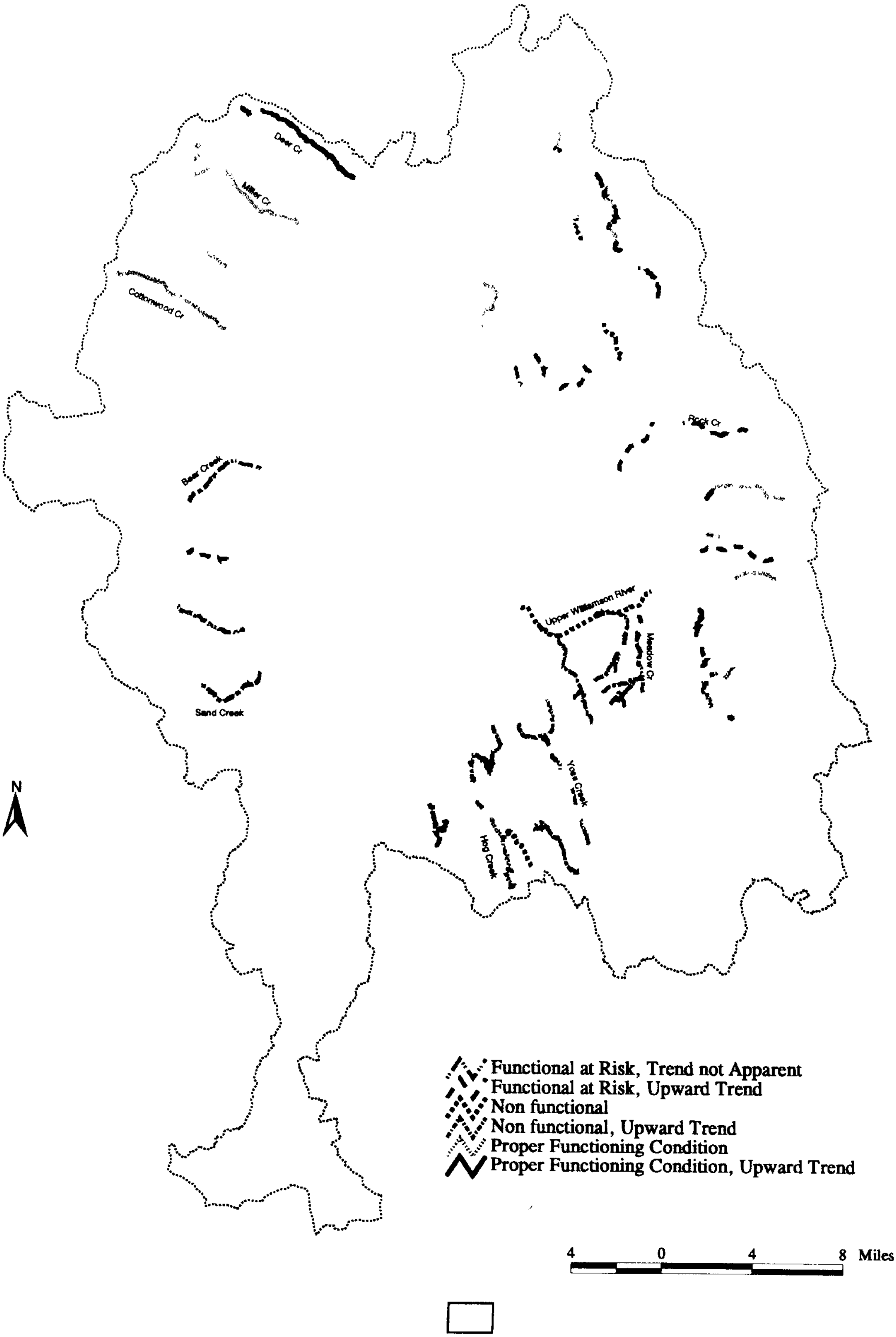
Riparian Habitats - The general trend for most riparian habitats, based on current range analyses conducted in 1992 and 1993, shows that most riparian communities are improving. These analyses were conducted on the Antelope Allotment on D1, and Skellock, Deep Creek, Yamsay, and Sycan Allotments on D2. More recent surveys using the rapid assessment process developed by the BLM, and endorsed by the Forest Service, confirm that most streams and associated meadows are improving. The graph below, and the map on the following page, show the functioning condition of the systems sampled within the analysis area (see Appendix D also).



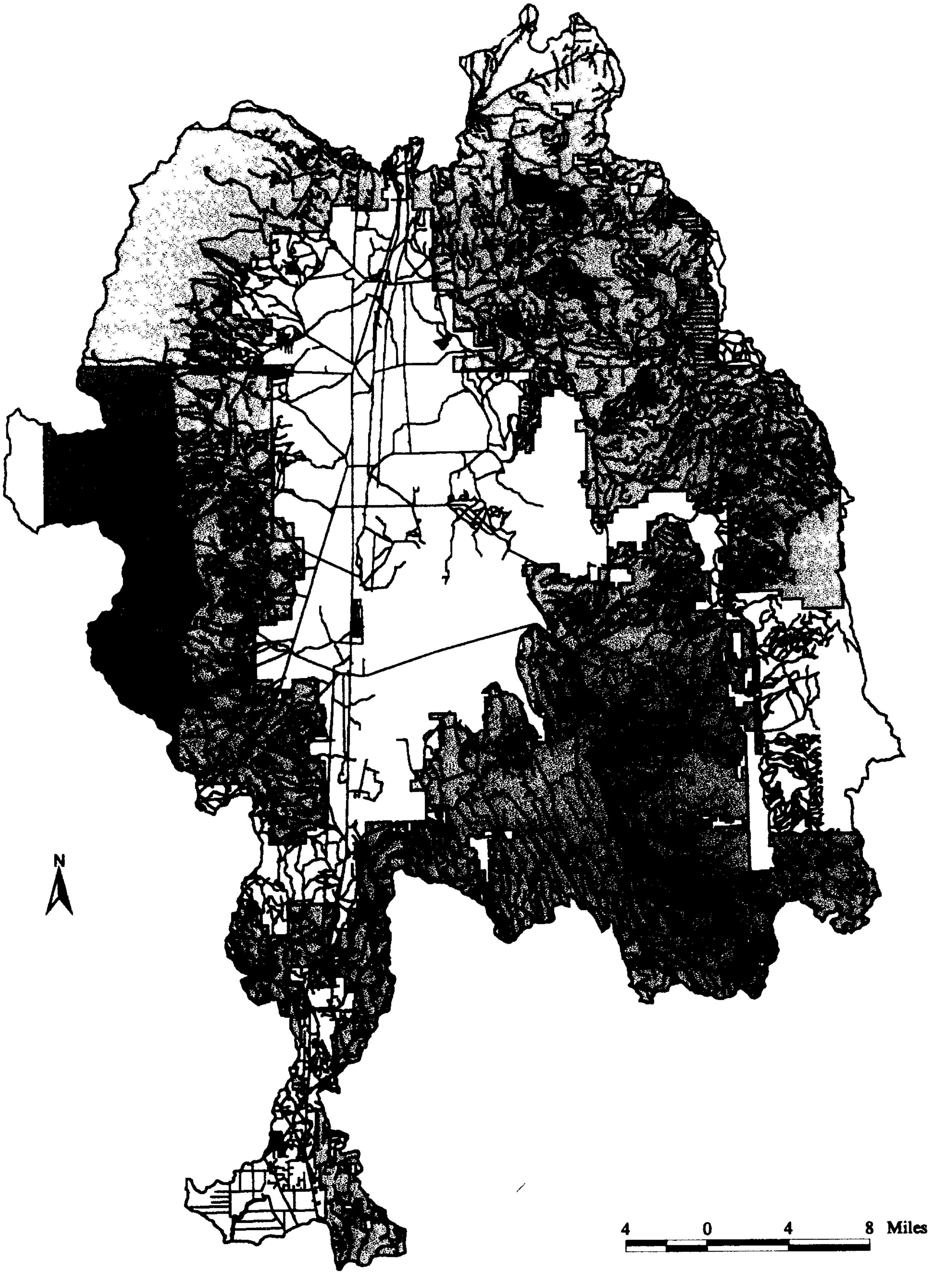
The overall greatest risk to these communities is the road systems that intersect and intrude on these habitats (see Road Density map next page, and Appendix E, Williamson River Subsheds Acres & Miles of Road Summary). The other major risk factor has to do with the drying out of the communities and consequent increase of conifer encroachment, increasing the chance of large wildfires.

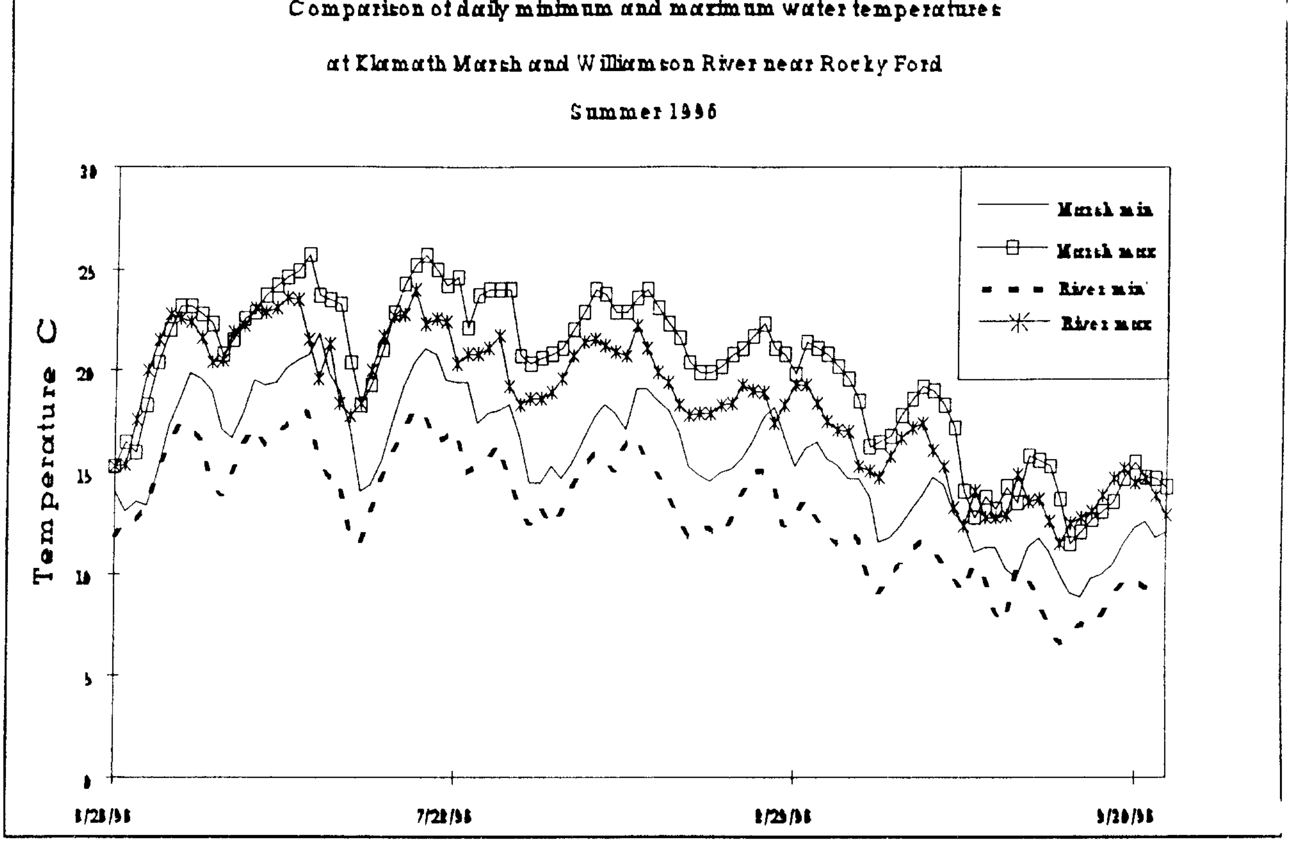
Riparian habitats are the main artery and lifeblood for all wildlife species. Examples of important wildlife that use these habitats include deer, elk, beavers, long-legged myotis, silver haired bat, peregrine falcons, prairie falcons, eagles, northern spotted owls, great gray owls, northern goshawks, bank swallows, purple martins, Schuh's homoplectrin (caddisfly), western toad and Cascades frog.

Riparian Condition Assessment



Road Density





Rocky Ford site is considered somewhat marginal habitat. Throughout this period redband trout were sampled at the marsh site. These fish showed good vigor, size and activity levels through the warm water period. Fish up to four pounds were sampled by hook and line at this site during mid-day through the heat of summer. The redband trout pictured on page 11 was taken from this monitoring site. This fish weighed approximately four pounds, and was 21 inches in length. If water temperature was limiting in this reach, one would not expect to find trout here.

Rearing Habitat

Summer rearing habitat experiences the same limitations as refuge habitat. It may extend further downstream, since fish tend to utilize forage habitat adjacent to refuge habitat, especially when refugia becomes over-crowded. During the cooler seasons these fish may range further downstream in order to take advantage of habitat that went under-utilized during the summer. The degraded channel areas appear to be very simple habitat, without features such as aquatic macrophytes that increase surface area for forage production. Unstable sediments common in the lower reaches are likely also marginal forage producers. Considering these conditions, the high quality rearing habitat probably is contained in the approximately seven miles of river from Wickiup Springs down to below the Deep Creek reach. The roughly eighteen miles of river below Deep Creek to Klamath Marsh is characterized as marginal rearing habitat due to its lack of productivity and inhospitable summer conditions over much of the reach. Rearing habitat within Klamath Marsh can largely be classified as nonfunctional because of degraded connectivity to the upper Williamson and the environment described in the marsh ecology section of this report. It is very difficult to quantify the marsh, as its size fluctuates so much with climatic cycles. If trout have access to the marsh, there would be a seasonal quantum increase in habitat size. Currently rearing habitat may be static to somewhat increasing due to land use improvements. As summer rearing habitat increases, there should be less crowding in the existing high quality habitat. This should produce more, and eventually larger fish, as the per capita forage base increases, possibly exceeding production capacity of the spawning habitat in the future.

Rainbow trout have been captured in Klamath Marsh (specifically at the Military Crossing Road and from Silver Lake Highway down to Soloman Flat) from spring through early summer, at least through the mid 1970's (Clinton Basey, personal communication) (Rod Johnson, USFS, personal communication). It is assumed these are upper Williamson stock that traveled downstream during favorable conditions, taking advantage of abundant forage in the marsh that is inaccessible during very warm or low water periods. This adfluvial behavior results in greater fishery productivity in the system by resting the upper river forage while utilizing the marsh's large forage base.

Access to the marsh, and a network of well defined channels in the marsh, are necessary for fish to utilize the forage base here. Factors discussed in the marsh ecology section illustrate reasons for disruption of this access.

Beaver most likely played an important role in channel maintenance and development in the southern half of the marsh, because the deeper water would provide a more perennial type of aquatic habitat. It is also their habit to develop numerous side channels in order to safely access food supplies (Olson and Hubert, 1994). These side channels produce forage for trout. Reduction of the marsh habitat reduces beaver activity in the southern half of the marsh.

Habitat Cover Components

Aquatic Macrophytes

Presently, submerged aquatic macrophytes add significantly to cover and forage production (both autotrophic and heterotrophic) substrata in the upper Williamson River. By adding structure to the areas of open channel, they provide habitat for invertebrates, substrate for algae, and become forage themselves. They also reduce sediment load by stabilizing stream substrata and directing flow into narrower channels around stands of plants. Fish utilize the edges of plant stands for cover.

Persistence of aquatic macrophytes in the river suggests their presence during the reference era. Channel damage since the reference era has increased siltation and decreased water clarity, resulting in a less hospitable environment for aquatic macrophytes. A 1979 survey performed for ODFW documents aquatic macrophytes at RM 73, and notes increased water clarity at the same point. Photographs upstream of this point also show reduced bank erosion. Additionally, the survey notes a drop in stream temperatures from approximately 63°F to 58-59°F in the same section. Darryl Gowan (USFS, personal communication) has observed only sporadic distribution of aquatic macrophytes downstream of Rocky Ford. Densities in the Sand Creek Ranch area are described as choking the channel (Steve Koon, personal communication). Macrophyte production in the lower reaches depend on recycled nutrients derived from the decomposition of organic material drifting downstream. Production of phytoplankton, specifically diatoms, gains the advantage in lower reaches as well. They tend to shade benthic (rooted) plants as well as compete for nutrients. Diatoms may gain a competitive advantage in part because of elevated siltation rates caused by riparian degradation in the middle reaches of the river below Deep Creek to the Royce Tract.

Currently, nitrogen is limiting autotrophic (plant) production in the river (see water quality section). Inorganic nitrogen is increasingly limiting downstream of the major springs, but recycling of bioavailable forms from decaying plants compensates somewhat for lowered inorganic concentrations. If the reference era river channel were more shaded, due to a narrower deeper channel with more stable overhanging banks and riparian vegetation, then rooted macrophytes would be more prevalent further down-river than today. Conversely, reference era aquatic vegetation would not be as dense upstream (closer to the springs) as the modern era. Thus, aquatic vegetation would have been more efficiently distributed, providing more cover and forage than today.

Several species of aquatic plant fragments were collected at the USFS road 49 crossing at T31S R10E S1 during winter, including: common elodea, whitewater buttercup, and water purslane. Plant fragments collected at the Silver Lake Highway crossing at T30S R10E S18 included common elodea, northern milfoil and pond weed. Positive identification of aquatic plants, and mapping their distribution in the upper Williamson, would be beneficial to maintaining and improving the river's aquatic environment. Identification should be done during the summer, when whole plants are available along with flowers. Since the plant fragments collected were not rooted, little can be said of the distribution of the samples except that they came from upstream.

Undercut Banks

In its pristine form, the pre-reference era river channel was most likely narrower and deeper than today, with nearly continuous undercut banks on the outside of each meander. These banks provide primary hiding cover which is especially important during stressful warm water periods. Removal of riparian vegetation has weakened the banks causing them to calve off, thus eliminating hiding cover. Some of the largest contributors to loss of bank stability and riparian vegetation include: man caused changes in hydrology, natural long term droughts, and overgrazing by livestock.

Riparian areas along the river on the Kittridge Ranch (T30S, R10E, S18) are thickly covered with willow. The original vegetation was also dominated by willow, according to Clinton Basey, ranch manager. The willows were removed because they posed access problems. More recently willows were allowed to recolonize, and have done so very successfully despite the presence of beaver (observed during summer 1996). The extent of willow dominance in this area suggests extensive coverage throughout the Williamson valley during the reference era. GLO survey notes from 1892 confirm large stands along the upper Williamson channel.

Watershed Continuity

With reference era Klamath Marsh elevations at spring runoff somewhat higher than currently, comes the possibility that more tributaries were aquatically connected than today. While a few feet in elevation seems minor, on a 0.02% slope, a few feet might make the difference between a losing and gaining final reach of some of the tributaries that do not currently connect to the river or the marsh. Losing reaches are areas where streamflow seeps into the ground at a rate higher than the stream can provide. Gaining reaches maintain or gain water due to seepage from the aquifer to the surface channel. Remnant channels, indicated on aerial photos of the mouths of streams such as Modoc and Sand Creek (east), tended to exhibit surface flow more frequently during periods when the Klamath Marsh and Williamson River water tables were higher. Well logs have documented long term groundwater fluctuations in Klamath Marsh as much as twenty feet during the twentieth century, with seasonal fluctuations of one to several feet (Leonard and Harris 1974). Long term area residents also have described the valley floor of the upper Williamson as being "spongy" even during the dry months during the 1950's. Tributaries such as Jackson and Sand Creeks (west side of marsh) very likely had aquatic connections during the late winter to early spring spawning period of redband trout.

Channel modifications where the river enters Klamath Marsh adversely affect the opportunity for recolonization and genetic exchange with fish from tributaries of the south end of the marsh, by deterioration of marsh habitat mentioned earlier. Hog and Yoss Creeks have had channels that connected to the river at least during spring runoff. These streams may have provided fish spawning and rearing habitat that is now lacking.

For the most part, the tributary streams flowing west into the river off Yamsay Mountain and Booth Ridge have cut channels to parent basalt type material, developing quality spawning gravel. In contrast, the main stem of the river consists mainly of ash and sediments, with limited spawning habitat. The Cascade drainages were separated from the marsh by Mt. Mazama, except for Sand Creek which was separated by irrigators. There are numerous natural reasons for a break in the connection of a stream from the river or the marsh, most of which would have happened prior to European settlement of the area. Breaks since the reference era have generally been human caused. The most obvious would be water diversion for irrigation e.g.: Jackson, Irving, Aspen, Sand (west), Big Springs and Deep Creeks. Not as obvious would be the lowering of groundwater elevation due to hydrologic change, ditching swampy areas to dry out pastures, grazing riparian areas which encourages channel incision, and removing riparian vegetation which maintained channels.

Specific Tributary Streams

For additional information on significant streams of the watershed see Appendix G, Specific Tributary Streams.

Reference Conditions

Terrestrial

Big Game - It is evident that the available screening in the ponderosa pine plant community was quite different prior to broad scale suppression of periodic wildfire than what we are attempting to manage for today. Numerous authors have described pre-suppression ponderosa pine stands as open, "park-like", with limited understory vegetation (Lieberg, 99; Munger, 17; Franklin and Dyrness, 73).

Understory conifers were far less prevalent and in much smaller patches than are represented under the present fire suppression regime. Large stands (greater than five acres) of even-aged conifers six to fifteen feet tall were rare, and occurred only following stand replacement events, which were also quite rare (Agee, 92). By our current definition (see Thomas, 79 and the ITAC mule deer model), hiding cover was virtually nonexistent in the ponderosa pine plant community, and greatly reduced in the dry lodgepole associations.

In the classic and much cited *Wildlife Habitats in Managed Rangelands-The Great Basin of Southeastern Oregon,* Leckenby et al (1982) describe optimum hiding cover as vegetation at least 24 inches tall and "...capable of hiding 90% of a *bedded* deer from view at 45 meters...". Though discontinuous and patchy, the pre-suppression pine forest provided cover in this form. Ecotonal moist lodgepole stringers or bottoms (such as Jackie's Thicket) fluctuated in stem density, often being thicket-like as a result of stand replacement outbreaks of insects, disease or periodic wildfires of various sizes. These sites were and are important cover areas for mule deer. Riparian corridors containing hardwoods and willows were extremely important for cover, forage and dispersal.

In his 1994 Elk Study, Foster notes that both elk and deer were present in eastern Klamath and western Lake County, at least since 1843 when Fremont made his second expedition through the area. Based on interviews of some local residents, during the 1920's and 1930's elk and deer did not appear in large numbers within the analysis area. During the 1950's and 1960's mule deer numbers increased significantly, followed by a general decline to the present time. As stated previously, elk numbers were fairly low in the analysis area until the early 1980's, and have been increasing since that time.

In regards to reference era elk and elk use, Roosevelt elk migrated over the Cascades into the Fort Klamath area and east of Hwy 97, following the riparian corridors during the spring, and migrated back over to the west side of the Cascades in the fall. This still occurs, but most of the Roosevelts were extirpated prior to 1910. Elk were reintroduced into the Cascades, but they were Rocky Mountain elk, and hybridized with the remaining native elk. So for all practical purposes, the present elk populations are not native, but introduced.

The shift in use from forbs to woody shrubs occurs in this area about mid July (Stuth and Winward, 77). Bitterbrush is the most important late-summer and fall forage species for mule deer in the watershed, and by far the most common non-coniferous plant in upslope ponderosa and lodgepole pine habitats. Bitterbrush, under a fire return interval of 15 years, did not develop to the robust 40" to 60" tall stature that is currently exhibited, but instead was represented by low growth to about 30 inches. Also, it did not attain the density that it does under the present fire suppression regime. Today's robust shrub form requires a high degree of energy for maintenance. Under a short fire return interval, annual leader growth is concentrated, succulent and easily accessible to browsing mule deer. Herbaceous forbs and grasses were more abundant under the ponderosa pine overstory (Franklin and Dyrness, 73), allowing a broader seasonal use of upland ponderosa sites by mule deer.

Eagles - Historically, eagle populations were probably more significant along the upper Williamson and upper Klamath Marsh until major road construction, ditching/diverting and draining occurred during the early 1900's, removing prey habitat. Also, the effects of pesticide use (DDT) for mosquito control, from the 1950's until its ban, probably affected eagles within the analysis area. Predator control using 1080 bait stations added to the problem, until also being banned.

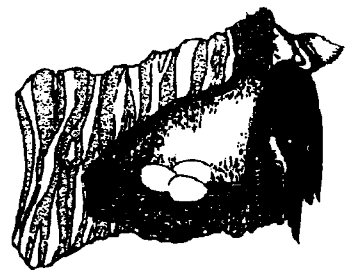
Goshawks - Goshawks use a wide range of habitats. Historically, this species may have used more riparian hardwoods prior to active de-watering combined with fire suppression. As conifer development and encroachment occurred in riparian zones, goshawks changed their nesting use areas. Smaller birds such as woodpeckers, waterfowl, etc., make up a large portion of the goshawk diet. This species probably has always been present, but never in large numbers.

Beaver - Davies (1961), has stated that beaver were present when early explorers came through the Klamath Basin in the mid-1800's, although not in large numbers like they were in other parts of the west. This could mean that they were at the lower end of their population cycle and most of the animals had moved on, since beaver populations are notoriously unstable. Beaver that were present may have been trapped as they were in other parts of the west.

Livestock were introduced into the area in the late 1800's, and their numbers increased and sustained during this century. Competition increased between livestock and beavers for the existing willow communities associated with the perennial water sources in the analysis area. This reduced and/or removed the willow communities along these sources. Other agricultural practices that contributed to the decline of existing beaver habitat include dredging/ ditching/channelization of stream projects that were designed to improve pastures for domestic stock. The overall effects from these activities has been a general lowering of the water table, in and outside the analysis area, changing some perennial streams to intermittent, or making them discontinuous in nature. Interviews with long-time residents of the area indicate there was no large mechanical equipment used to remove willows from the riparian system, as has occurred in other areas. There is no documentation that displays mechanical removal of willows, but this does not mean that it did not occur. It did occur in other parts of Klamath County. The practice of ditching, combined with season-long or year-long grazing in willow dominated areas accomplished the same thing; willow removal from the riparian systems.

Northern Spotted Owl - Historically there never was very much habitat east of the higher slopes of the Cascade Range, due to the periodic fire regime and the open grown ponderosa pine stands. Most of the mixed conifer stands occurred in very small patches, 10 acres or less, on the buttes east of Hwy 97. Only excess birds migrated east, and their survival rate was not very high. This is due to the spotted owl's inability to defend itself against other raptors and owls, which make it very vulnerable to these predators.

Woodpeckers - Open grown ponderosa pine tends to have more broken tops, double tops, and spike tops. This probably provided more habitat for white-headed, and Lewis woodpeckers, and secondary cavity nesters such as the pygmy nuthatch, and the pygmy and flammulated owls. Black-backed and northern three-toed woodpeckers were more dependent on the few old growth lodgepole pine associated with the riparian stringers that are common across the analysis area. This was subject to fire events, also.



Bats - Reference conditions were probably optimum for these mammals, since the open-grown ponderosa pine provided ideal roosting day habitat, and the riparian areas provided an abundance of flying insects

Falcons - The main limiting factor for falcons, both peregrine and prairie, is nesting habitat. Presently the only peregrine nesting sites are inside Crater Lake National Park. Prairie falcons have been located on Yoss Creek Ridge, Oux Kanee Overlook, and the Williamson River Canyon. In the past, some of these areas may have been used by peregrines. There may have been other areas on D1 that were used by peregrines or prairie falcons, such as some of the canyon areas in Cottonwood Creek, or some of Ramsay Mountain's steep drainage areas that have rocky ledges.

Wolverines, Fishers, and Martens - These species were more prevalent in reference times, prior to trapping, habitat modifications, and increased human activities. Fishers, and wolverines are very intolerant of human disturbance, and do not mesh well with the increased human presence.
It is suspected, as with other predators, that the prey base and their territorial nature, probably limited these species presence in reference times, until active trapping and habitat modifications started occurring.

Wolves, Grizzly Bears, and Lynx - These predators were present during the reference era, but were extirpated by the early 1900's. The last grizzly was killed about 1920, and the last recorded sighting of a lynx was in Fort Klamath (outside the analysis area) in 1932. Wolves were also eliminated during this time frame.

Aquatic

Klamath Marsh

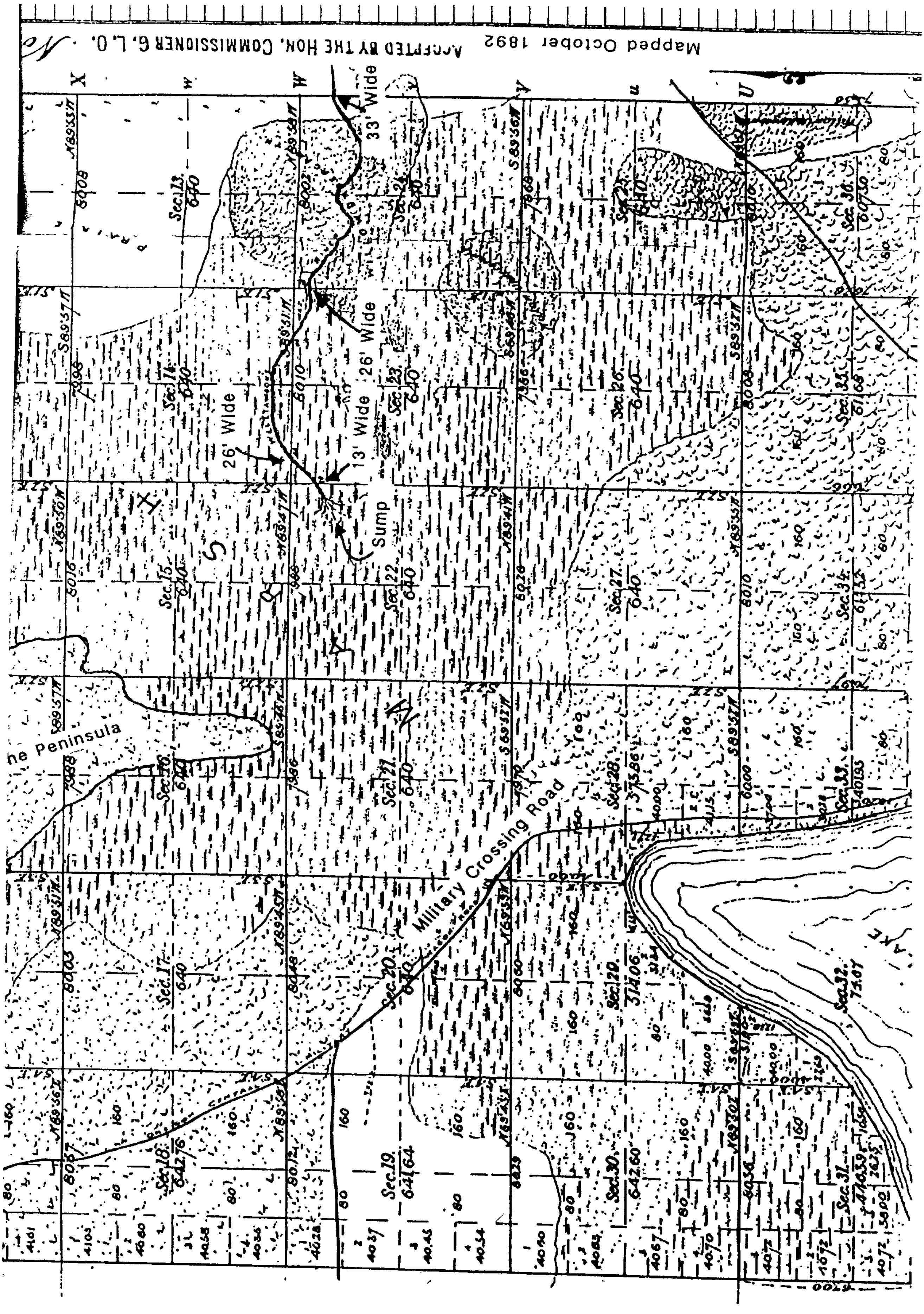
Maps created by the Government Land Office (GLO) during the 1860's and 1890's indicate a network of natural channels, springs and swamps entering Klamath Marsh mainly from Big Springs, Sand Creek (west) and the Williamson River. Sand Creek and Big Springs supported the west side, with the Williamson supporting the north side of the marsh. Further description is offered by Colville (1902) who estimated 10,000 acres of continuous wocus covered marsh. GLO maps and survey notes dated October of 1892 indicate the edge of open water at an elevation of 4,515 feet in the vicinity of the Military Crossing, with water depths of two to four feet in the area. The October timing of the open water observations indicate the roughly 10,000 acres of open water were perennial, since September and October are the low water months of the year. In late August 1855, Williamson and Abbot (Abbot 1857) described the marsh as "a strip of half submerged land, about twelve miles long and seven miles broad...covered by clumps of tule and other aquatic plants separated by small sheets of water".

The 10,000 acres of wocus mentioned by Colville indicate a large area of water too deep for emergent vegetation to develop. Texts indicate wocus prefer water from 1 to 2.5 meters deep (Guard 1995). They did not report how much of the year this water depth was required. This depth precludes establishment of emergent vegetation and indicates a range of depths for the open water area of the marsh. This open water area is very similar in size to the modern Agency Lake.

Abbot's description of a twelve mile long marsh likely involves only the area he observed on the southern portion of the marsh, south of where the upper Williamson River enters the marsh and the Peninsula area, which divides the southern and northern marsh areas. After the Mt. Mazama eruption dammed the marsh, the hydraulic control point near Kirk began eroding, causing the standing water in the marsh to recede, and the upper Williamson River channel extended itself and formed an alluvial fan where it contacted the slack water of the marsh or its ancestral lake. This phenomenon isolated the northern area of the marsh from the river channel, and caused it to be an emergent marsh or wet meadow area. 1892 GLO survey notes indicate the river subs into the marsh in a southwest trajectory in sections sixteen and seventeen, just east of the peninsula. The river decreased from thirty-three feet wide to zero within approximately two miles. This water likely entered a layer of pumice under the peat soils of the marsh which would have been deposited by the Williamson. The GLO 1892 map (next page) indicates a likelihood that much of the water resurfaced near the Military Crossing. The river water may have resurfaced in numerous springs across the marsh as well. The marsh north of the peninsula units should be considered separately because of the hydrological difference from the area south. In 1892 the north area of the marsh was described by the surveyors as a bulrush swamp. Due to evidence presented here, and information from Clinton Basey [who stated that the original canal constructed in the north end of the marsh (the Kittredge Canal) was designed with the sole purpose of drying up the north end for pasture]; no evidence was found of a natural channel connecting the north area of the marsh with the south. This indicates that the north end was hydrologically isolated from the southern portion and should naturally be considered a terminal basin with minimal aquatic interaction with rest of the marsh. The bulrush dominance described by the 1892 GLO surveyors indicates an anaerobic emergent marsh. Discharge from such an environment results in high concentrations of humic material which has a high biological oxygen demand. Increased oxygen demand is detrimental to eutrophic (biologically productive) environments since it can cause oxygen poor dystrophic conditions found in modern Klamath Marsh.

In December of 1843, Captain John C. Fremont characterized the military crossing area of the marsh: "The point on which we were encamped forms, with the opposite eastern shore, a narrow neck, connecting the body of the lake with a deep cove or bay which receives the principal affluent stream, and over the greater part of which the water (or rather ice) was at this time dispersed in shallow pools. Among the grass, and scattered over the prairie lake, appeared to be similar marshes. It is simply a shallow basin, which, for a short period at the time of melting snows, is covered with water from the neighboring mountains; but this probably soon runs off and leaves the remainder of the year a green savannah, through the midst of which runs the river Tlamath (sic), which flows to the ocean, winds its way to the outlet on the southwestern side."

While none of these descriptions are definitive, they do describe a variably wet environment in winter and summer, with a definite potential for connected aquatic environments during some seasons. The reference era marsh delivered relatively cool, nutrient rich water to the major areas of open water habitat. This phenomenon most likely created a eutrophic environment somewhat similar to Agency and Klamath Lakes before they were dammed and developed. With connecting channels to colder water refuge habitat, and a productive open water habitat available, it is very likely that the rainbow trout of the Klamath Marsh drainage thrived in this environment. In fact, tribal history of the area confirms



Mapped October 1892
ACCEPTED BY THE HON. COMMISSIONER G. L. O.
33' Wide
26' Wide
26' Wide
13' Wide
Sump
he Peninsula
Military Crossing Road
Sec.13. 640
Sec.14. 640
Sec.15. 640
Sec.16. 640
Sec.17. 640
Sec.18. 642.76
Sec.19. 641.64
Sec.20. 640
Sec.21. 640
Sec.22. 640
Sec.23. 640
Sec.24. 640
Sec.25. 640
Sec.26. 640
Sec.27. 640
Sec.28. 373.86
Sec.29. 314.06
Sec.30. 642.60
Sec.31. 476.39
Sec.32. 73.01
Sec.33. 401.35
Sec.34. 611.53
Sec.35. 616.8
Sec.36. 607.30

the presence of large salmonids in the upper Williamson River. These fish were most likely adfluvial stocks that spent much of the year in Klamath Marsh, then migrated out when conditions deteriorated during warm weather and drought. The upper Williamson, Big Springs and Sand Creek (west) were the primary warm season cool water refugia.

Large areas of the marsh flooded during winter and spring runoff events. In this way the marsh stored water to slowly release later. During these cold water runoff events, metabolic rates of the marsh vegetation is slow, so nutrient concentrations in the water are only slightly depleted by plant production. Much of the water seeps into the ground, then resurfaces in the channels as the weather warms, as cool nutrient-rich water. This water source provided the eutrophic conditions in the open water that were very conducive to fish production.

The open water area covered with wocus that Colville speaks of was maintained by the degree and longevity of spring flooding which discourages establishment of emergent vegetation. Additionally, the aerobic upstream habitat and high wind exposure oxidize humic compounds in receiving water, which increases bioavailable nutrients and water clarity (by reducing humic stain). Especially in shallow lakes, wind can mix water and reduce surface tension in order to greatly increase oxygen diffusion into the water column. Available oxygen breaks down complex organic molecules into forms available for primary production (photosynthesis). Emergent vegetation insulates standing water from the wind and shades the water. Both of these phenomena reduce the ability of standing water to maintain oxygen concentrations and recycle nutrients.

Nutrients were recycled efficiently and rapidly during the reference era. Because of the network of channels that probably existed historically, the marsh soils, except those underlying the open water, were drained during dry summer and fall seasons. Marsh soils were largely peat, which developed from decomposing emergent aquatic and wetland vegetation. Aerobic decomposition in drained marsh soils proceeds at an order of magnitude faster than anaerobic soils which underlie more permanently flooded sites. Phytoplankton (submerged and floating leaf vegetation found in open water) readily break down into simple bioavailable nutrients due to their minimal lignified (carbon) structure. The end result becomes more inorganic and simple organic nutrient sources, much more available for primary production than the incomplete by-products (humic material) common with anaerobic decomposition. Naturally channelized water also delivers nutrients more efficiently across the marsh to the open water, since dissolved nutrients are not spread over large areas of emergent vegetation which would use and tie them up during the growing season. Therefore, a great deal of bioavailable nutrients were present and utilized for phytoplanktonic and submergent aquatic plant production, which in turn resulted in a rich eutrophic environment, producing fish on a par with those found in Upper Klamath and Agency Lakes.

With more complete decomposition of organic matter comes reduced levels of the brown color humic stain in the water. Humic compounds are primarily the result of incomplete decomposition of emergent marsh vegetation due to anaerobic conditions. Reference era water in Klamath Marsh had significantly less brown stain. This allows increased light penetration into water and more bioavailable nutrients, resulting in greater production of phytoplankton, and ultimately aquatic fauna such as fish. The modern marsh would produce many more fish if it were more aerobic, but anaerobic conditions preclude the majority of aquatic fauna including fish. According to Elizabeth Budy (Winema National Forest Archaeologist) early explorers reported small fish being a food source of marsh residents. Spot observations during the summer of 1996 indicated a lack of fish in general, except for introduced catfish in the stagnant river channel at Kirk.

The ecology of Klamath Marsh, including its watershed, is quite dynamic. During dry cycles, the upper Williamson River is the main tributary to the marsh. During wetter climates, Big Springs reaches a par with the Williamson as the largest tributary, according to Clinton Basey, a resident of the area since the 1940's. During a drought cycle in the early twentieth century, Big Springs completely dried up. Since water from Big Springs is high in phosphorus and low in nitrogen content, the primary contribution of Big Springs is temperature and oxygen. During wetter cycles Big Springs provides a large source of cool water for refuge habitat in the marsh, as well as extending the period of favorable habitat conditions for trout production in the open water habitat. Trout grow to a larger size with more rearing time in the open water. There are less Blue-green algae (cyanobacteria) blooms as well, due to lower water temperatures, which favor green algae in this phosphorus rich water. During dry cycles, blooms of cyanobacteria are likely greater in magnitude, thus increasing nitrogen content and productivity of the water, due to their ability to fix atmospheric nitrogen as water temperatures rise above 20°C. This augmented productivity may not be fully realized as fish production if high water temperatures limit the growing season in the marsh. However, a portion of this augmented production may be stored as either biota or bioavailable nutrients until the habitat returns to favorable conditions, when it may then be utilized.

Trout

Most of the upper Williamson probably had high quality habitat, with more stable sediments and undercut banks supported by extensive stands of riparian vegetation. Summer refuge and rearing habitat were much more extensive, providing a less stressful environment with more forage per capita, producing more and larger trout. Jackson and Irving creeks may have been connected to the river during the spawning season, providing up to four or five miles of spawning and early rearing habitat. The river was better connected to Klamath Marsh, which provided several thousand acres of rearing habitat. Considering the additional available habitat, one might conservatively estimate a two to four-fold increase in trout population, and at least that much in biomass. These additional fish would be distributed throughout the river all year, and in the marsh during the cooler seasons.

In order to describe the genetic stock of rainbow trout that inhabit the upper Williamson River and Klamath Marsh, a description of the environment in which these fish evolved is required, since the organism is defined by the environment it inhabits. Both the current and historical environment must be considered to understand the factors that shaped the present form of life.

According to Behnke (1992), redband trout invaded the Columbia Basin during the late Pleistocene approximately 30,000 years ago, just before or during the last major glacial advance. The trout were most likely present in the Klamath Marsh drainage before the eruption of Mt. Mazama approximately 7,700 years ago. This is evidenced by the genetic difference from Upper Klamath Lake stocks, and that the two stocks do not appear to intermingle. Had Klamath Lake stock invaded the marsh after the Mazama eruption, then the upper Williamson stock would be genetically similar. According to Buchanan et al (1994), the closest relatives to upper Williamson stock reside upstream of Sycan Marsh and in Cold and Beaver Creeks, which are tributaries of Jenny Creek above a barrier waterfall.

Using well logs from Leonard and Harris (1974), isopachs (pumice depths) found in Williams (1942) and personal communication with Dave Sherrod, (USGS, Geologist) a reconstruction was developed of the bathymetry of the ancient lake from which Klamath Marsh evolved. Historical shorelines on the east side of the marsh along Wocus Bay indicate water levels up to twenty-six feet above the current marsh elevation. Williams (1942) indicates the occurrence of pyroclastic flows from Mt. Mazama across the marsh at Kirk. USGS quad maps indicate a possible pyroclastic dam there, to an elevation of 4,600 feet. The current hydraulic control is at 4,510 feet. Ash deposits on the west side of the marsh, at present surface elevations of 4,520 feet, are on the order of 50 to 60 feet deep. From this information it was concluded that lake depths might have ranged from roughly 50 feet deep before the eruption, to possibly 80 to 90 feet just after the eruption. Since the pyroclastic material is fairly erodible, the post Mazama maximum depth probably eroded quickly down to denser material, thus the shorelines developing at twenty-six feet. The current control of the marsh is a basalt reef at Kirk, which is at the head of a canyon carved in basalt. It is assumed this was the approximate level of the hydraulic control before the eruption of Mt. Mazama.

Regardless of exact depths, a shallow broad lake bathymetry is indicated, with excellent solar exposure to the south. Thus far, information dating the historic shorelines has not been available, so the rate of lake to marsh evolution is not known. From this information it appears the redband trout of the upper Williamson River evolved with access to a large, shallow lake that was probably very productive because of its shape, solar exposure and adequate supply of limiting nutrients. Considering alluvial deposits that underlay the most recent Mazama deposition, the lake has probably been large and shallow at least since the end of the last major glacial advance 10,000 years ago, and depending on the rate of alluvial deposition, possibly several times longer.

Considering this possible history, the marsh lake represented a very rich source of forage for fish. The most successful individuals would be able to take advantage of this forage base for the greatest length of time during the growing the season. Thus, it would be very advantageous for fish to tolerate warm water, in order to maximize genetic fitness by increasing body mass, which increases fecundity. This argument is further supported by the idea that the upper Williamson River had a narrower channel, with more overhanging banks and riparian vegetation than the modern river exhibits. Historically the river was more shaded, which limited biological productivity. Limited productivity in the river encouraged adfluvial behavior, in order to improve genetic fitness.

Organisms evolving in similar environments have a tendency to develop similar traits, regardless of their genetic relation. The Wood River stock of redband trout represent an intermediate form between the upper Williamson redbands and the Upper Klamath Lake redbands (Buchanan et al, 1994). Agency Lake is important foraging habitat for the Wood River stock. The lake currently averages only three feet deep, with a maximum depth of seven feet (Johnson et al, 1985). Since the surface elevation is the same as Upper Klamath Lake, the dam on Upper Klamath has some effect on the depth of Agency lake. The lake elevation has been raised by as much as three feet by the dam (Mike McNeil, USFS, Hydrologist, personal communication). Accounts from the early twentieth century describe Agency Lake as a marsh or prairie during dry climates (Elizabeth Budy, USFS, Archeologist, personal communication). This describes an environment similar to reference era Klamath Marsh. Wood River redband trout grow to a much larger size than would be expected if they spent their entire life in the river. These fish also persist in the upper end of Agency Lake longer than the cool water season. It is expected that redband trout from the upper Williamson have the same tendency to utilize Klamath Marsh when sufficient water and channel development are available. They likely also share an ability to tolerate elevated water temperatures. This was mentioned earlier regarding the 1996 monitoring site near Klamath Marsh and the elevated temperatures those fish tolerated.

Redbands from Paradise Creek, in the upper Sycan River drainage, are closely related to the upper Williamson stock (Buchanan et al, 1994). In a 1992 USFS stream survey of Paradise Creek, redbands were observed to temperatures of 80°F. Although Paradise Creek is much smaller than the Williamson, it still has spring fed headwaters for the fish to escape high temperatures.

Synthesis and Interpretation

Terrestrial

Forest management objectives include providing quality habitat for wildlife, healthy forest stands, quality functioning streams, and healthy riparian zones. Other objectives of the Forest are to provide a sustainable economic base locally, and an esthetically pleasing environment for the public to enjoy. Along with these objectives, the Forest is mandated to provide habitat for big game that will allow Klamath Tribal members to exercise their treaty rights as part of the consent decree on former reservation lands.

In order to meet these objectives, the Forest has implemented the following actions in accordance with the Forest Plan, The Northwest Forest Plan, and Eastside Screens :

✓ Set aside areas for species of concern (i.e. eagles, goshawks, northern spotted owls)
✓ Provided buffer and protection measures for management indicator species
✓ Prescribed fuel treatments
✓ Restricted livestock use
✓ Reduced the number of active grazing allotments
✓ Stopped harvesting old growth conifers (21"+ DBH or greater)

Other actions include:

✓ Conducting surveys and assessments of current riparian conditions and timber stand conditions
✓ Surveying project areas for wildlife species of concern, so that as funds become available, corrective measures can be implemented, such as:
  * Reducing miles of road and/or modifying riparian road crossings
  * Thinning from below to reduce incidence of wildfire conflagrations along with maintaining healthy stands
  * Reestablishing riparian hardwoods and other native species by planting, burning, or using cuttings from established plants

Obstacles or resource conditions that may not allow the Forest to achieve these objectives include the miles of open system and non-system roads within the area. These open road systems range from three miles/section up to five or six miles/section, and have from one to seven riparian crossings that may need modifying so that water can access the entire riparian area. For example, on D1 the 94 road has at least seven riparian crossings that should be considered as potential modification projects. On D2, the 49 road also has seven riparian crossings that should be considered.

Other obstacles that are road related include:

- ✓ Sensitive resources that preclude ground disturbing activities (i.e. road obliterations) from occurring outside the road prism
- ✓ Public, other Forest users, and Klamath Tribal concerns and resistance to closing roads that are used for their activities
- ✓ Restrictions of Forest management activities still does not preclude public access on restricted use roads during the restricted use time period
- ✓ Projects that need to use a particular road scheduled for closing delaying the road closure (i.e. fuel treatment access needs)
- ✓ Funding availability to do the planning and implementing of proposed road projects
- ✓ Flat terrain that dominates the landscape often precludes establishment of effective physical road closures.

Some or all of the above obstacles also apply to other projects that are designed to improve resource conditions. These projects include broadcast burning, thinning from below, and habitat improvement projects (i.e. snag creation, forage improvements).

Disagreement between agencies, governments, and professional resource managers over proper management of and/or methods of improving habitats contributes significantly to keeping habitats in less than desirable conditions.

Private and/or other ownership and management of large areas of both upland and riparian habitats can significantly affect habitat conditions for some species of wildlife by keeping habitat conditions in less than optimum conditions. Examples include overly large harvest areas and extended grazing without rotation of livestock to prevent over-utilization of forage resources. On the other hand, private and/or other ownership can provide benefits to wildlife such as providing protection from extended hunting and fishing, limiting access, entering into cooperative improvement projects that improve habitat conditions along streams and managing their activities to protect selected wildlife.

Successional pathways of some riparian plant communities have been changed from reference times, and will not move back towards the reference pathways due to introduced species altering the path. Some native plant species cannot compete with these introduced species (i.e. tufted hairgrass cannot compete with Kentucky bluegrass). Willows generally do not establish very well on downcut channels, since the water table is below their effective rooting zone.

The entrenched and/or downcut areas within a meadow or floodplain allow drier site plants to establish and extend their range within the riparian zone. The downcut area then becomes the wet plant zone, and the area above that will dry out and allow those plants that are adapted to drier site conditions to become dominant. There are numerous reaches of downcut/entrenched perennial and intermittent systems within the analysis area. Examples on D1 include Davis Flat, Rakes Meadow, O'Conner Meadow, Jack Creek above Jamison Ranch, Bear Creek. D2 examples include Skellock Draw, Deep Creek, Aspen Creek, Upper Williamson at the old Rocky Ford and on the Royce Tract. Most of these areas are improving, but are following a different successional path than in the reference era.

Other obstacles to improving habitat and resource conditions include management directions to provide habitat for species that are not compatible (such as providing habitat for goshawks and northern spotted owls on the same acres, and/or trying to improve forage conditions for big game while also trying to maintain an old growth stand with a crown closure greater than 41%). These conflicting directions can be worked through, but tend to cause delays in implementing the best strategy for all resources.

Changes that have occurred within the analysis area are a combination of events over time combined with human activities and their intervention and interruption of natural processes. The most obvious has been the interruption of natural fire regimes. The primary reasons have been to protect timber resources in an effort to gain more growth and production. The other common interruptions are the road systems that criss-cross the riparian systems, and the ditching, diverting, and changing of the water movement to and through riparian systems. The primary reasons have been to improve access for timber harvesting, improving riparian areas for pasturing and growing livestock, and to provide water for domestic use. The resultant changes to these habitats (upland and riparian) has benefitted those species of wildlife that were adapted to the conditions that have been created, and has reduced or eliminated those species that could not adapt. The table below lists the changes to habitats and human activities that have contributed to population declines of some wildlife species.

Factors Contributing to the Decline of Terrestrial Species of Concern within the Williamson River Basin Analysis Area

Conversion of late and old seral stands to younger seral stands:
Great gray owls, flammulated owls, pygmy owls, boreal owls, spotted owls, white-headed woodpeckers, black-backed woodpeckers, Lewis woodpeckers, Williamson's sapsucker, pileated woodpeckers, northern goshawk, merlin, Yuma myotis, pallid bat, fringed bat, silver-haired bat, long-legged myotis, long-eared myotis, hoary bat, marten, fisher, western gray squirrel, pygmy nuthatch.
Decrease in the numbers of >20" dbh ponderosa pine trees:
Flammulated owl, pygmy owl, white-headed woodpecker, Lewis woodpecker, Williamson's sapsucker, Yuma bat, pallid bat, fringed bat, silver-haired bat, long-legged myotis, long-eared myotis, hoary bat, western gray squirrel and pygmy nuthatch
Decrease in the numbers of >20" dbh mixed conifer trees:
Same species as above; plus spotted owl, pileated woodpecker, goshawk, marten and fisher
Fragmentation - smaller habitat patches, reduced continuity of riparian corridors, more edge habitat, longer dispersal distances between patches, more openings within patches:
Spotted owl, Williamson's sapsucker, pileated woodpecker, goshawk, merlin, Yuma bat, pallid bat, fringed bat, silver-haired bat, hoary bat, long-legged myotis, long-eared myotis, wolverine, marten, fisher, pygmy nuthatch, grouse, passerines, and beaver
Degraded riparian habitat - loss of large tree and down wood structure, loss of riparian hardwood communities, conversion of wetlands to pastures, loss of water storage capabilities, changing peak flows to shorter, and earlier time frames:
Bald eagle, bank swallow, northern goshawk, great gray owl, Lewis woodpecker, greater sandhill crane, fisher, beaver, cascade frog, western toad, Schuh's homoplectran, Cascades apatonian caddisfly, purple martin, mule deer, elk, grouse, and Vaux's swift

Introduction of, competition by, and predation from non-native species: Lewis woodpecker, purple martin, deer, bank swallow and black-chinned hummingbird
Decrease in the amount of large, down wood: Pileated woodpecker, wolverine, marten and fisher
Plant species shift from ponderosa to fir: Flammulated owl, white-headed woodpecker and Lewis' woodpecker
Disturbance: logging, agricultural practices (grazing, ditches, diversions), transportation systems (railroads, roads), people (population, activities), etc: Great gray owl, peregrine falcon, prairie falcon, yuma bat, pallid bat, fringed bat, silver-haired bat, long-legged myotis, long-eared myotis, hoary bat, wolverine, fisher, bank swallow and deer
Dependent on others for cavity construction: Flammulated owl, pygmy owl, boreal owl and purple martin
Year-long hunting: Deer and antelope
Naturally small population size: White-headed woodpecker, peregrine falcon, prairie falcon and purple martin
Extirpated: Gray wolf, lynx and grizzly bear
Transitional forage areas converting to cover: Deer, elk and antelope

Table excerpted from the Mazama Watershed Analysis, Chemult Ranger District, WNF.

The entire analysis area has been subjected to prolonged fire suppression activities since the mid to late 1920's. One affect has been to increase plant densities/acre. There are only a few relic areas in the ponderosa pine type that still show characteristics of pre-fire suppression; i.e, large diameter trees 20"+ dbh, little understory growth, and large open spaces between trees. Examples of these types of areas occur in the upper panhandle area west of Hwy 97 between Pothole Butte and Scott Creek along the 2308 rd., the northwest slopes of Ramsay Mtn. above Jackson Creek (T30S, R11E, parts of Secs 9, 10,14, 15), a small area on the north side of bull pasture (T32S, R10E, sec25s1/2), and Wildhorse Ridge between Skellock Draw and the Silver Lake Highway.

The mixed conifer component, as stated previously, has expanded its range on the buttes, and mountains within the area, completely or partially displacing former ponderosa pine sites. Examples include Applegate Butte, Solomon Butte, Calimus butte and Yoss Ridge on D2. D1 examples include Ramsay Mountain, Walker Rim, Sugar Pine Mountain and Boundary Butte. This change has been brought about by the combination of two practices; selective logging (harvesting primarily ponderosa pine), and fire suppression. These practices have allowed some wildlife species such as pileated and black-backed woodpeckers, northern spotted owls and hawks to extend their area of use, but due to cyclic drought and insects and disease, these areas become at high risk to fire. The other effects of mixed conifer expansion is the reduction of upland hardwood species such as Scouler's willow and aspen. These hardwoods are important in the moister sites, providing diversity to a conifer dominated landscape, nesting/perching habitat for some neotropical migrants, and upland forage and cover for big game.

The lodgepole pine component has expanded its range into both the ponderosa pine and riparian habitats. The key reasons for this have been selective harvesting of ponderosa pine, extended fire suppression activities, cyclic drought conditions, and road systems that tend to change water movement into and through riparian communities, further drying these formerly moist and wet areas. This allows the lodgeepole to become established or increase stocking levels. The result of this movement into riparian areas has been to reduce the hardwood component and some grasses, forbs, and sedges. Examples of this conversion are common across the entire analysis area. The old growth lodgepole component has been reduced in both the upland and riparian habitats by past timber and firewood harvesting. Both districts have had timber harvests extending into riparian communities. Firewood gathering occurs more frequently in riparian communities on D2 than on D1 in recent years. Extensive removal of this component reduces habitat for black-backed woodpeckers and secondary cavity nesters, and perching and nesting habitat (18"+dbh riparian lodgepole) for eagles and great gray owls. Extensive removal of riparian lodgepole can destabilize intermittent and perennial streams when access roads and heavy livestock use are allowed to remain in place following tree removal.

Examples of streams that have had lodgepole removed are Jack Creek on D1, and the Williamson River on D2. The best example of dead and down lodgepole holding a system together is the Miller Creek outlet from Miller Lake. Dead and down lodgepole provides habitat for a large variety of species including frogs, amphibians, insects, big game, furbearers, woodpeckers, owls, and rodents.

Changes to riparian plant communities have been the result of cyclic drought conditions, extended inundation combined with past season-long livestock grazing (still occurring on private lands), road systems that parallel and cross through these communities, extended fire suppression activities, timber harvesting, ditching/diverting water from streams, and increased water demand and use by new residents moving into the area. This has altered the water flows into and out of the upper marsh, probably the key riparian zone within the analysis area, and the one area where the Forest Service has little opportunity to improve conditions. Key changes that have occurred from ditching/diverting have resulted in less water reaching the marsh from streams such as Sand and Scott Creeks on the west side of the marsh, and Williamson River, Deep, Sand, Irving and Jackson Creeks on the south and east side of the marsh. The result of these activities has been to change the riparian plant communities on the systems, lower the water tables, and decrease the time and volume of flow from the marsh to the Lower Williamson River and Upper Klamath Lake causing an overall loss of riparian hardwoods, native grasses, sedges, and rushes. This in turn has resulted in the loss of nesting, rearing and foraging habitat for some species of caddisflies, amphibians, molluscs, reptiles, seasonal migrating waterfowl, cranes, eagles, and other raptors. Some species of wildlife such as Canada geese, mallard ducks, and big game have been able to adapt to the changes and maintain fairly stable populations, but other species such as Peregrine falcons, goshawks, beavers, great basin spadefoot, spotted-frogs, long-legged myotis, and sandhill cranes have lost some or all of their ability to fully utilize, or successfully produce offspring in these modified riparian habitats.

The distribution and abundance of wildlife species reflects the overall health of the riparian systems, and in turn the health of the riparian systems reflects the overall functionality of the processes at work within the landscape. This in turn affects the systems and processes dependent on this landscape, i.e, the lower Williamson and Upper Klamath Lake.

Aquatic

Klamath Marsh

When Europeans arrived in the mid nineteenth century they began a program of diverting water on marsh lands and wetlands in the watershed in order to dry pastures early in the growing season. Land was then irrigated later in the growing season to increase available pasture, accomplished by diverting and ditching water. Transportation was improved by developing roads across the marsh. Fire suppression since the early twentieth century has greatly increased the density of area timber stands. As a result, shade and thermal cover increased, while wind exposure decreased. Evapotranspiration from overstocked forests annually removes runoff water during the portion of the growing season when it is available to the rooting zone of the trees, usually from April into July. The effect of all this, along with a naturally variable climate, has been to modify the timing, duration and magnitude of peak flows that maintain the marsh and create the lake type of environment in the southern area of the marsh. Natural channels have disappeared because flows that maintained them have been altered or removed and have choked off with vegetation. Less water reaches the marsh during the critical dry summer season due to reduced groundwater storage. This is caused by modified spring runoff, evapotranspiration on irrigated sites, diversion of tributaries, loss of irrigation water over the edge of the lens that supports the surface water table of the marsh, ditching, and channel incision in wetlands higher in the watershed due to overgrazing in riparian zones. Some ditches on Sand Creek on the west side of the marsh appear to have diverted water off the original lens and may lose water to a deeper aquifer under the marsh.

The biological consequences have been less pooling of spring runoff waters in the southern area of the marsh so that any lake that now forms is shallower, smaller and of a shorter duration. Channels and connected pools that provided connectivity of the marsh with refuge habitat of the tributaries are drastically reduced. Large areas of wocus and open water have been replaced by tules and other emergent vegetation which characterize shallow water. Emergent vegetation intercepts limiting nutrients that are necessary for production of plants and animals in the previously open water habitat. Rearing habitat for aquatic fauna is greatly reduced in size and longevity. Runoff water storage along the perimeter of the marsh has been reduced due to a lower maximum elevation of the lake that forms and maintains the marsh during spring runoff. This also caused the marsh to become smaller. Each incremental increase in lake depth floods a large area of land due to the flat marsh topography. Summer flows of water from shallow groundwater reservoirs in wetlands and meadows higher in the watershed have been reduced due to ditching and channel incision caused by over-grazing in riparian zones.

Water chemistry has been modified to greatly reduce simple compounds required for photosynthesis, thus most phytoplankton and submergent vegetation suffer from lack of bioavailable nutrients. The modified marsh, now dominated by emergent vegetation and lacking in natural channels, produces large quantities of lignified (high carbon content) emergent vegetation. These plants use more oxygen to decompose into bioavailable forms because of increased structure necessary for an aerial existence. The result is humic compounds that are products of incomplete decomposition of plants. These large organic molecules also chemically tie up limiting nutrients such as nitrogen and phosphorus. They also stain the water brown and reduce light transmission necessary for photosynthesis in the water column. Production of fauna that rely on aquatic food sources is greatly reduced because of the reduction of photosynthesis. Humic compounds were historically present in areas of the marsh with anaerobic soils between the open water and the well drained aerobic soils of seasonally flooded marsh. They were most likely not as dominant as they have been during the modern era, and the aerobic nature of the marsh had more capacity to decompose the humic material.

Greater production of humic material has also resulted from fire suppression. A decrease in fire frequency allows accelerated buildup of duff on the forest floor and more decaying vegetation in meadows and marshes. Historically much of this material was oxidized by fire into more simple compounds which were either driven into the atmosphere or remained as ash and potentially entered the groundwater. Today increased amounts of duff has increased leaching of humic material from the forest floor downstream into the streams and marshes of the watershed during spring runoff, thus increasing the oxygen demand necessary to decompose these substances. This exacerbates the current situation in Klamath Marsh. Productivity of meadows also benefits from this release of simple compounds that are readily available for biological production. Riparian areas which are wetter than surrounding forests may get as many strikes as the surrounding forest, but will not burn as frequently due to elevated moisture. Dry climate cycles may be important by creating conditions conducive to fires in riparian areas. Many of the lowland streams in this watershed have large meadow and marsh systems. Currently most of them produce humically stained waters. The humic concentrations may decline with increased fire frequencies of dry climate cycles.

Fire suppression in the watershed has reduced burn frequency within Klamath Marsh as well. Historically fires must have periodically burned marsh vegetation and peat thus counteracting both the natural and human caused filling of the marsh with peat. Prescribed fire should be considered as a viable option to maintain or create deep water habitat which is lacking in the modern marsh. Hugh Null, the manager of the USFWS refuge has described holding handfuls of burning peat that he could still squeeze water from. This is an indicator of the ability of peat to dry itself while burning, and its ability to burn down into deeper peat deposits in order to create deeper habitat when the area floods again.

Because bioavailable nitrogen has been bound in humic compounds (thus rendered unavailable for photosynthesis) before all phosphorus supplies are exhausted, there are blooms of nitrogen fixing blue-green algae in the remaining open water habitats of the Marsh. Blue-green algae (cyanobacteria) are considered rare in humically stained waters. Because of the high phosphorus content of the region's groundwater, blue-green algae exists in Wocus Bay. Since cyanobacteria rely on fixing atmospheric nitrogen once water temperatures reach approximately 20°C, and since nitrogen is the main limiting nutrient to biological production, increased biological enrichment (eutrophication) is experienced from this point downstream. This is true until the aquatic environment in the open water becomes anaerobic at the decomposition layer of the sediment-water interface. This causes a switch to de-nitrification which releases nitrogen to the atmosphere. This is a summer phenomena which likely happens after effluent flows over the reef at Kirk have ceased.

A modern example of the effect of a wet emergent marsh can be seen where the Military Crossing Road crosses the marsh. The ditch channel that crosses the road on the eastern side of the crossing was constructed along an alignment that would emulate the original Williamson channel. The area along this channel is well drained and flooded for a shorter time in the spring. Water in this ditch is of a greenish milky color indicating a relatively dense population of phytoplankton in the water column. The channel that crosses the road on the west side of the crossing drains the north basin of the marsh that the Fish and Wildlife Service has flooded using a canal from the river. The area it drains is flooded for most of the year and the vegetation is dominated by emergents. This water is the typical dark brown transparent water seen in most of the marsh. This example illustrates the potential for the Williamson and other tributaries to deliver high quality water far into the southern portion of the marsh, as well as the potential for the deeper water areas of the marsh to have been a biologically productive aerobic environment, complete with aquatic fauna similar to the upper Williamson. GLO maps from 1892 indicate the Williamson channel subs just east of the peninsula, then reemerges in a large bay area immediately south of the peninsula down to the Military Crossing. This eutrophic environment has been replaced with a largely dystrophic, (oxygen poor) emergent dominated environment in the north end of the marsh that is poor fish habitat. The naturally open water habitat in the southern portion of the marsh historically made use of the Williamson water along with large amounts of surface and groundwater from the west side tributaries to create a very productive aquatic system. The north end of the marsh offers negligible assistance from its tributaries to support a productive environment there. Subsurface water contributed by tributaries such as Sand Creek (west) that resurfaces in the marsh provided oxygen rich cool water for refuge habitat that likely supported fish in the marsh throughout the year. This is a distinct contrast from water that runs over the surface of fields thus producing warm dystrophic water that dominates the modern marsh.

Downstream Ecological and Chemical Effects of Klamath Marsh

As more of the marsh is driven to anoxia by modern land management, water discharge from the marsh tends to contribute more eutrophying nutrients such as nitrogen and phosphorus to the lower Williamson and eventually Klamath Lake. This is explained by chemical interactions in the sediment-water interface. Anoxic sediments underlying oxidized water will tend to hold the soluble (reduced) forms of phosphorus and nitrogen in the sediment. When the overlying water becomes anoxic, the soluble forms of phosphorus and nitrogen escape the sediment to the water column and may travel downstream out of the marsh (Wetzel, 1983). Some of the nitrogen will volatilize into the atmosphere in the form of ammonia, but much of it will continue on downstream. As discharge is aerated by the river and lake below the marsh, these elements become available once again for production of vegetation. This incremental production contributes to the eutrophication and degradation of Upper Klamath Lake, including the endangered sucker habitat downstream of Klamath Marsh.

One main factor contributing to anoxic conditions in Klamath Marsh is decreased water flow, largely caused by water diversions and potential effects of overstocked forest stands. Two activities the federal government has control of are the diversion of the Williamson River into the formerly terminal basin at the north end of the marsh, and timber stocking levels of the surrounding watershed. Since the north end of the marsh (north of the peninsula) was most likely a terminal basin, it can remain an emergent marsh by disconnecting the constructed channels which fill and drain the north end. This would trap the sizable quantities of nitrogen and phosphorus which would naturally occur in a terminal marsh. Nutrient leaching to the south end of the marsh would be drastically reduced and less nutrients will reach critical habitat for Klamath Basin endangered suckers downstream of the marsh.

Reconnection of the upper Williamson to its natural channel, which entered the south section of the marsh near the peninsula, may be the single largest step currently available to recreate a more aerobic environment in the southern (main) portion of the marsh and reduce nutrients responsible for degradation of downstream aquatic endangered species habitat. Research will be needed to further quantify the effect of Klamath Marsh on the eutrophication of the watershed downstream.

In the very simplest terms it may be speculated that irrigating roughly twice the area of Klamath Marsh with the same amount of water as naturally occurred, should have some significant ecological impact.

Trout

The most significant causes of change since the reference era include hydrological and habitat modification caused by: forest management or timber harvest, fire suppression, livestock grazing, wetland reclamation, road construction, climatic fluctuation, and introduction of exotic species.

Climatic conditions and hydrologic modification in the watershed have resulted in long term water table fluctuations of up to twenty feet during this century. Extended drought periods, along with overgrazing, have resulted in large amounts of stream bank failures and increased siltation. Much of the habitat degradation discussed here has resulted from the cumulative effect of these factors. Water table fluctuation also directly impacts habitat volume. Much of the channel incision on the river is attributable to a low water table. During the early part of this century extended drought caused Big Springs, on the northwest side of Klamath Marsh, to cease flowing above ground.

Timber harvest in the watershed has dramatically modified the composition of upland vegetation, which has some as yet unquantified effect via its impacts on evapotranspiration, shading, wind exposure and thermal insulation. Extensive road construction in the watershed also has an influence on groundwater contribution and timing of surface runoff where road systems extend stream networks in non porous soils.

Livestock production impacts the fishery resource in several ways. Habitat has been modified by the breaking down of streambanks and removal of riparian vegetation, eliminating much of the undercut banks, and increasing siltation. This has led to broader shallower streams with less hiding cover, forage production and rooted aquatic macrophytes, along with more phytoplankton and warmer water. Trout have abandoned reaches with this combination of impacts. Flood irrigation for livestock production also warmed and reduced base flows due to increased solar and atmospheric exposure. Irrigation diversions have disconnected some tributary streams from the river and the marsh (Jackson, Irving and Sand (west) Creeks), possibly eliminating spawning and juvenile fish habitat, as well as cool water refugia at the former confluences.

Channels cut in fine sediments such as silt and volcanic ash tend to cut vertically when the channel is disturbed. The upper Williamson has such a low gradient, that along with a couple of erosion resistant reefs that control the river, the channel responds by becoming wider and shallower instead of cutting down. This results in greatly reduced cover for fish. Regardless of forage production and proper temperatures, a stream with no hiding cover will not produce fish. Ultimately these channels lose their definition and become braided. According to data collected by the Klamath Tribes (Craig Bienz, personal communication) the Williamson River above Deep Creek is exhibiting this trend.

Wetland reclamation has removed areas from aquatic forage production and severed aquatic access to formerly connected habitats for aquatic fauna such as fish. Wetlands also augment water storage and supply additional shallow groundwater during the warmer seasons.

Exotic species of fish introduced into the watershed include brook, brown and hatchery stocks of rainbow trout. These fish are effective competitors to redbands. Brook trout are very competitive in smaller tributaries, the high quality habitat in the upper Williamson, and in streams in the Cascades. They appear to have displaced redbands in Jackson Creek and are dominant in Deep Creek. If Jackson Creek were connected to the river, brook trout would likely have a negative impact on juvenile redbands rearing in Jackson Creek. Jackson Creek would probably have a similar mix of brook and redband trout as Deep Creek. Brown trout are prevalent in Sand, Scott and Miller Creeks as well as Miller Lake. If the Sand and Scott Creek watersheds were reconnected to the marsh, brown trout may pose a competitive problem to redbands in the marsh. Domestic strains of rainbow trout may hybridize with the redbands, degrading their ability to utilize habitat of this watershed.

Recommendations

Based on the present conditions of the resources and habitats that are present in this area and the time and funding limitations that are inherent with implementing restoration activities, it is imperative that projects and activities be designed to get the greatest value for the efforts expended. Further realization that implementing these projects comes under the scrutiny of different agencies, governments, publics, and internal reviews, requires a great amount of persistence and patience.

Roads:

With the above side boards and parameters in place, the primary areas to focus on are the perennial systems that can be improved with a moderate investment of time and energy. For example, on D1: the road crossings on Cottonwood, Scott, and Bear Creeks should be monitored to see if first of all, the crossing is really needed. If so, determine if culverts are of proper size to handle the high spring flows and are not causing aggrading, if the crossings should be improved so that upstream debris does not jeopardize the crossing, and if the culverts are at the proper angle. Some culverts are higher on the downstream side than the upstream. D2 road crossings on perennial streams involve both County, private, and Coop Road Management with other users, where most of the maintenance of roads and crossings have been assigned to other user groups. Examples are the Williamson River and Deep Creek. There are not very many opportunities for D2 to correct road problems on perennial streams, other than looking at ways to minimize user and secondary roads paralleling these systems on public lands, and/or minimizing road effects on riparian zones adjacent to these streams.

Both districts have a multitude of riparian crossings on intermittent systems. Priorities for determining needs of crossings and/or modifications will be more appropriately handled through the analysis and planning of timber harvests, natural fuels treatments and thinning projects. The road crossing work may be companion or mitigation projects for these other activities. System road crossings should be dealt with first, user roads second. These potential projects should be assessed as to their overall importance to perennial systems or any indicator species or species of concern using these areas, or if there is potential for these species to increase use of an area by modifying, closing, or changing the location of the crossings.

There may be some opportunities to work with adjacent landowners to improve road crossings that access their land and are used by this agency to access work or project areas, under cooperative projects [i.e. US Timberlands (formerly Weyerhaeuser) D1, D2; Iverson (Jamison Ranch) D1; Deep Creek Ranch, D2].

Look into cooperative efforts between other agencies such as ODFW, Klamath County Visitor's Center and Klamath Tribes, to distribute flyers/brochures explaining the effects of off-road vehicle traffic on riparian communities, and the wildlife dependent on these communities.

Internally distribute flyers attached to wood permits, mushroom permits, etc., alerting users to avoid off road vehicle activities, along with educating them about the effects this has on these communities and dependent wildlife.

Initiate cooperative studies to determine if there is any difference in wildlife use and/or habitat effectiveness between roaded riparian areas and non-roaded, or restricted road access in riparian areas [i.e. Sugar Pine Mountain Restricted Access Area (D1); and Skellock Draw (D2)].

Forage and Habitat Improvements:

* Use prescribed fire to manage riparian habitats (improve vigor of meadow communities, stimulate willow and/or aspen growth).

* Use prescribed fire to manage upland habitats (maintain old growth trees by reducing competition for understory conifers and brush, and encourage upland forbs, grasses and new bitterbrush plants from existing sources).

* Continue efforts of rehabilitating cut banks, raw banks and drainages with willow plantings, cuttings and sedge transplanting where conditions allow for successful establishment.

* Explore using native materials such as lodgepole, instead of fences, for livestock and off-road vehicle barriers for protection of sensitive areas. This should reduce maintenance costs associated with fencing.

* Clear understory vegetation (ladder fuels) away from snag patches to maintain integrity of snag patches for longer periods of time and avoid wildfire conflagration.

* Look for opportunities to pursue cooperative habitat improvements with other agencies and adjacent landowners.

* Monitor all projects to determine successes and failures, so future projects can be designed for success.

Other Studies, Surveys, Monitoring:

* Pursue cooperative studies between agencies, and user groups on Species of Concern. [i.e. deer forage study (D1,D2); American marten study (D1)]; winter bald eagle survey (D1,D2)].

* Pursue potential cooperative study to determine spotted owl dispersal habitat and habitat conditions that need to be improved in matrix lands for owl dispersal.

* Continue present surveys for Species of Concern, and entering data into oracle database.

* Develop experimental tracts of timber to better understand impacts of over-stocked forests on hydrology and aquatic systems.

Fish Habitat

* Characterize habitat and monitor change via a continuing program of Level II stream surveys.

* Since habitat currently occupied by fish is a result of random fish stocking practices, many historically fishless sites are now fish bearing. Fishless perennial habitat is now much less common and should be protected due to its uncommon community structure. Invertebrate surveys should be conducted to identify ecologically valuable systems that evolved without fish. These habitats should be afforded the same protection as fish bearing habitat. An example of a rare species is the federally listed category two caddisfly Apatania tavala which was sampled in Sand Creek (west) by Wisseman (1991, 1992).

* Develop and refine riparian cultivation techniques in riparian zones. Then assist other landowners to implement successful techniques across the watershed where they are applicable.

* Identify critical aquatic refugia habitat via high resolution thermal infra-red aerial photographic analysis. Identify discrete features by using remote thermographs.

* Maintain connectivity of tributaries via a healthy water table and prevention of mass sedimentation of the tributaries' lowest reaches by improper road construction and land use practices.

* Further refine impact of factors negatively affecting Klamath Marsh hydrology and aquatic ecology. Then treat the largest sources of degradation.

* Expand the US Fish and Wildlife Service burning program on Klamath Marsh in order to emulate the natural fire regime that helped naturally maintain deeper water habitat and counteract human caused filling of the marsh with vegetation and peat.

* Improve stream edge cover by deep planting riparian hardwoods and sedges. One idea for rehabilitation of riparian hardwoods is to drill into the banks four feet, with native willow stock, in order to establish vegetation on the outside bends of the river. Mike McNeil, USFS Hydrologist, believes the raw banks may erode as much as one foot per year. By rooting deep into the bank, the

starts get time to establish before the soil erodes. It is logical to expect erosion rates to slow as root structure development begins to armor the banks

* Stabilize channel and reduce sediment load on the river, lower Deep Creek, and wherever future surveys indicate the need, by deep planting riparian hardwoods and sedges and actively managing livestock use of riparian zones. One technique might be sedge and rush plugs placed in the banks to stabilize them. Beaver shouldn't significantly damage planted sedge and rush since they're not as palatable as willow, and there is currently a great deal of sedge available. These plants grow quickly and have excellent root mass. There is some concern that sedge only root in the wettest soil and would vegetate only a narrow band of a steep incised bank. When undercuts form under vegetation, the overhanging bank may be vulnerable to sloughing off if the water level drops sufficiently below the roots of the riparian vegetation. It seems that upper bank weight could cause the banks to slough if they aren't buoyed up by the water during dry climate cycles. Roots need to travel deep into the bank in order to effectively protect the overhang. With willow starts drilled into the bank four feet, a strong tie-in would be more assured. If beaver eat the willow starts, the roots of deep planted starts may survive so the plant can regenerate. Ideally they will only eat what is exposed, instead of pulling the whole start out of the bank.

* Improve midstream cover via downstream expansion of submerged aquatic macrophyte community by improving channel stability and reducing sediment load.

* Investigate the potential for an aquatic connection of Jackson Creek to the river, at least during the spawning and out-migration periods. If spawning habitat can be reestablished, brook trout should be eradicated from the creek to eliminate competition that could preclude reproductive success of redbands.

* Survey Deep Creek for rainbow trout spawning activity.

* Improve fall through spring forage habitat by insuring channel connection to Klamath Marsh and continuity of marsh channels; particularly the Williamson, Big Springs and Sand Creek confluences with the marsh.

* Differentiate between temperature and cover as habitat limiting factors by comparing fish densities in cooler water areas with little cover, to warmer areas with more substantial cover.

* Utilize prescribed fire in forest and riparian areas to reduce timber stocking levels to near reference era conditions and reduce decadent meadows in, order to improve water yield and quality.

<u>Threatened and Endangered Aquatic Species</u>

* Survey the watershed for Miller Lake Lamprey and conduct a life history study to identify methods of habitat improvement.

* Continue with habitat improvement projects.

REFERENCES

Abbott, H L 1857 Report of Lieutenant Henry L. Abbott, Corps of Topographical Engineers, upon explorations for a railroad route from the Sacramento Valley to the Columbia River, 1855. Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean U S Documents Set 763 Washington, D C

Behnke, R J. 1992 Native Trout of Western North America. American Fisheries Society Monograph 6.

Blackwood, T , K.E. Baitis, M Reiter, T.R. Turner, and R J Danehy. 1996 Deep, Sand, Aspen and Coyote (Creeks) Watershed Analysis Weyerhaeuser Co , Tacoma

Buchanan, D V , A R. Hemmingsen, D L Bottom, R.A French, and K.P Currens. 1989. Native Trout Project Oregon Department of Fish and Wildlife Research Project F-136-R, Annual Progress Report, Portland.

Buchanan, D V , A.R. Hemmingsen, and K.P Currens. 1994. Native Trout Project. Oregon Department of Fish and Wildlife Fish Research Project F-136-R-07, Annual Progress Report, Portland.

Carlson, Garwin 1979. Soil Resource Inventory Winema National Forest, Pacific Northwest Region, Winema National Forest, Klamath Falls

Coville, Frederick V. 1902. Wokas, a Primitive Food of the Klamath Indians. Report of the National Museum, 1902, pp 727-739. Washington D.C.. Smithsonian Museum.

Davies, K.G., ed.. 1961. Peter Skene Ogden's Snake Country Journal, 1826-27, vol. 23. Hudson's Bay Record Society, London

Eastman, D. L.. 1974. Summary of Summer Track Count 1964 - 1974 "Sprague Unit". Oregon Department of Fish and Wildlife. Aug, 1974.

Foster, Craig L.. 1994. Final Report Fort Rock/South Central Elk Telemetry Study. Oregon Department of Fish and Wildlife. Aug, 1994.

Frazier, Brent D.. 1994. A Historical Summary of Livestock Grazing on Former Lands of the Klamath Tribes Currently Part of the Winema and Fremont National Forests. Winema National Forest Document. April, 1994.

Fremont, B.J.. 1845. Report of the Exploring Expedition to the Rocky Mountains in the Year 1842, and to Oregon and California in the Years 1843-44. S. Exec. Doc. 174, 28th Congress, 2nd Session, Washington, D.C..

Hemmingsen, A R , D V Buchanan, D.L Bottom, R A French, K P Currens, and F C Shrier 1988 Native Trout Project Oregon Department of Fish and Wildlife. Fish Research Project F-136-R, Annual Progress Report, Portland.

Inman, Jack. 1980. Winema Inter-Agency Coordination of Management Objectives for Mule Deer of Fort Rock, Silver Lake, Sprague, Klamath Falls, and Keno Units. Winema National Forest Document Nov, 1980.

Johnson, D.M., R.R. Petersen, D.R. Lycan, J.W Sweet, M.E Neuhaus, and A.L. Schaedel. 1985. Atlas of Oregon Lakes Oregon State University Press Corvallis

Leonard, A R. and A.B. Harris. 1974. Ground Water in Selected Areas in the Klamath Basin, Oregon. USGS, Klamath County and Pacific Power and Light

Minckley, W.L , D.A. Hendrickson, and C.E Bond. 1986 Geography of Western North American Freshwater Fishes Description and Relationships to Intracontinental Tectonism. Pages 519-613 in Hocutt, C.H and E O Wiley, editors, The Zoogeography of North American Freshwater Fishes, John Wiley and Sons, New York.

Nelson, C.H., P R Carlson, and C.R. Bacon. 1988. The Mount Mazama climactic eruption (approx. 6900 yr B.P.) and resulting convulsive sedimentation on the Crater Lake caldera floor, continent, and ocean basin. Geological Society of America Special Paper 229.

Olson, R. and W A. Hubert. 1994 Beaver water resources and riparian habitat manager. University of Wyoming. Laramie.

Oregon Department of Fish and Wildlife Big Game Population Status Reports. 1995.

Rosgen, Dave. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO.

Salinas, J.. 1985. Miller Lake: A Limnological Survey. Report CAS-9502. Winema National Forest, USDA. Klamath Falls, Oregon.

Spier, Leslie.. 1930. Klamath Ethnography. University of California Publications in American Archaeology and Ethnology, Volume 30.

Stern, Theodore. 1966. The Klamath Tribe: A People and Their Reservation. University of Washington Press, Seattle, Washington. 356 p.

Tonsfeldt, Ward. 1987. Mills along the Lakeshore: The Lumber Industry on the Winema Lands 1910-1936. Report prepared under Winema National Forest contract #53-04U3-6-0007. On file Winema National Forest, Klamath Falls, Oregon. 202 p.

Tonsfeldt, Ward. 1995. Reconnaissance and Evaluation of Historic Railroad Systems, Chiloquin and Chemult Ranger Districts, Winema National Forest. Report prepared under Winema National Forest contract #53-04U3-1-00055. On file Winema National Forest, Klamath Falls, Oregon. 264 p.

Troendle, C A 1986 The Potential Effect of Partial Cutting and Thinning on Streamflow from the Subalpine Forest Tes Pap RM-274 Fort Collins, CO. U S Department of Agriculture. Forest Service, Rocky Mountain Forest and Range Experiment Station

USDA Forest Service. 1995 Forest Service National Resource Book on American Indian and Alaska Native Relations - Working Draft 1995 USDA Forest Service, Washington DC. p. 76

USDA Forest Service, PNW. 1983. Guidelines for Sampling some Physical Conditions of Surface Soils p. 34

USDI, BIA 1930-1947 BIA Grazing Summaries, Klamath Indian Reservation.

USDI, BLM 1993. Riparian Area Management. Process for Assessing Proper Functioning Condition Technical Reference 1937-9 p 51

USDI, BLM 1994 Riparian Area Management Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas. Technical Reference 1737-11 p 37

USGS. 1992 Chemical Analyses of Surface Water Samples in Upper Klamath Basin - Nutrient Assessment Study Portland, OR.

Williams, H . 1942 The Geology of Crater Lake National Park, Oregon. With a Reconnaissance of the Cascade Range Southward to Mount Shasta. Carnegie Institution of Washington Publication 540, Washington D.C .

Whaley, Wayne H. & White, Clayton M 1994. Trends in Geographic Variation of Cooper's Hawk and Northern Goshawk in North America: A Multivariate Analysis, Volume 5 Number 3, Western Foundation of Vertebrate Zoology.

<u>Winema National Forest Records</u>

Subregional Ecological Assessment Team Report
Forest Recreation records for Head of the River and Jackson Creek Campgrounds

<u>Chiloquin District Records</u>

Deep Creek, Skellock, and Yamsi Allotment Files.

<u>Chemult District Records</u>

Jack Creek Allotment File

BIBLIOGRAPHY

Abbott, H.L.. 1857. Report of Lieutenant Henry L. Abbott, Corps of Topographical Engineers, upon explorations for a railroad route from the Sacramento Valley to the Columbia River, 1855. Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean. U.S. Documents Set 763. Washington, D.C..

Baldwin, Ewart. 1964. University of Oregon Cooperative Bookstore, Eugene, Oregon.

Behnke, R.J. 1992. Native Trout of Western North America. American Fisheries Society Monograph.

Belsky, A. Joy and Blumenthal, Dana M. 1996. Effects of Livestock Grazing on Stand Dynamics and Soils in Upland Forests of the Interior West.

Bienz, Craig 1997. Summary Graphs and Charts of Deer Herds and Harvests in Southern Oregon, based on Klamath Tribes and Oregon Department of Fish and Wildlife population status reports.

Blackwood, T., K.E. Baitis, M. Reiter, T.R. Turner, and R.J. Danehy. 1996. Deep, Sand, Aspen and Coyote (Creeks) Watershed Analysis. Weyerhaeuser Co., Tacoma, WA.

Brown, Carroll. n.d. History of the Rogue River National Forest. On file Winema National Forest, Klamath Falls, Oregon.

Buchanan, D.V., A.R. Hemmingsen, D.L. Bottom, R.A. French, and K.P. Currens. 1989. Native Trout Project. Oregon Department of Fish and Wildlife Research Project F-136-R, Annual Progress Report, Portland.

Buchanan, D.V., A.R. Hemmingsen, and K.P.Currens. 1994. Native Trout Project. Oregon Department of Fish and Wildlife Fish Research Project F-136-R-07, Annual Progress Report, Portland.

Carlson, Garwin.. 1979. Soil Resource Inventory Winema National Forest, Pacific Northwest Region, Winema National Forest, Klamath Falls.

Coville, Frederick V.. 1902. Wokas, a Primitive Food of the Klamath Indians. Report of the National Museum, 1902, pp 727-739. Washington D.C.. Smithsonian Museum.

Davies, K.G., ed.. 1961. Peter Skene Ogden's Snake Country Journal, 1826-27, vol. 23. Hudson's Bay Record Society, London.

Eastman, D. L.. 1974. Summary of Summer Track Count 1964 - 1974 "Sprague Unit". Oregon Department of Fish and Wildlife. Aug, 1974.

Foster, Craig L.. 1994. Final Report Fort Rock/South Central Elk Telemetry Study. Oregon Department of Fish and Wildlife. Aug, 1994.

Frazier, Brent D.. 1994. A Historical Summary of Livestock Grazing on Former Lands of the Klamath Tribes Currently Part of the Winema and Fremont National Forests. Winema National Forest Document. April, 1994.

Fremont, B.J.. 1845. Report of the Exploring Expedition to the Rocky Mountains in the Year 1842, and to Oregon and California in the Years 1843-44. S. Exec. Doc. 174, 28th Congress, 2nd Session, Washington, D.C.

Gatschet, Albert S. 1890. The Klamath Indians of southwestern Oregon. Government Printing Office, Washington, DC. P Xxiii

Greene, Linda W. 1984. Historic Resource Study, Crater Lake National Park, Oregon. United States Department of the Interior. Denver, Colorado.

Lebo, David. Botanist for US Forest Service and Bureau of Land Management. 1997. Personnel communications.

Guard, B.J. 1995. Wetland Plants of Oregon and Washington. Lone Pine Publishing. Redmond, Washington.

Hemmingsen, A.R., D.V. Buchanan, D.L. Bottom, R.A. French, K.P. Currens, and F.C. Shrier. 1988. Native Trout Project. Oregon Department of Fish and Wildlife. Fish Research Project F-136-R, Annual Progress Report, Portland.

Hocutt, C.H. and E.O. Wiley, editors, The Zoogeography of North American Freshwater Fishes, John Wiley and Sons, New York.

Hopkins, William E.. 1979. Plant Associations of South Chiloquin and Klamath Ranger Districts, Winema National Forest. USDA Forest Service publication R6-ECOL-79-005.

Hutchinson, G.E. 1957. A Treatise on Limnology Vol.(1). Pub. John Wiley and Sons, Inc. New York.

Inman, Jack. 1980. Winema Inter-Agency Coordination of Management Objectives for Mule Deer of Fort Rock, Silver Lake, Sprague, Klamath Falls, and Keno Units. Winema National Forest Document.

Johnson, D.M., R.R. Petersen, D.R. Lycan, J.W. Sweet, M.E. Neuhaus, and A.L. Schaedel. 1985. Atlas of Oregon Lakes. Oregon State University Press. Corvallis.

Klamath Agency. 1910-1930. Published in Report of the Secretary of the Interior, Exec. Doc., H.R. Congress of the United States. Typescript. Microfilm in Library, Univ. of Oregon. Cited in Theodore Stern. 1966. The Klamath Tribes. The University of Washington Press, USA.

Kovalchik, Bernard L. 1987. Riparian Zone Associations of the Deschutes, Ochoco, Fremont, and Winema National Forests. USDA handbook.

Leonard, A.R. and A.B. Harris. 1974. Ground Water in Selected Areas in the Klamath Basin, Oregon USGS, Klamath County and Pacific Power and Light.

Magazine Article: Interstate Wildlife Study ... a fresh perspective. Mzuri Safari Foundation. Study conducted by Department of Forestry and Conservation, UC, Berkeley.

Meiman, J.R. Influence of forests on snowpack accumulation. In: Management of Subalpine Forests: Building on 50 Years of Research. USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins Colorado. General Technical Report RM-149.

Minckley, W.L., D.A. Hendrickson, and C.E. Bond. 1986. Geography of Western North American Freshwater Fishes: Description and Relationships to Intracontinental Tectonism. Pages 519-613 in Hocutt, C.H. and E.O. Wiley, editors, The Zoogeography of North American Freshwater Fishes, John Wiley and Sons, New York.

Moore, Al. 1945. Outline of a Wildlife Management Plan for the Klamath Indian Reservation. Fish and Wildlife Service.

Nelson, C.H., P.R. Carlson, and C.R. Bacon. 1988. The Mount Mazama climactic eruption (approx. 6900 yr B.P.) And resulting convulsive sedimentation on the Crater Lake caldera floor, continent, and ocean basin. Geological Society of America Special Paper 229.

Olson, R. and W.A. Hubert. 1994. Beaver: water resources and riparian habitat manager. University of Wyoming. Laramie.

Oregon Department of Fish and Wildlife Big Game Population Status Reports. 1995.

Perdue, E.M., C.R. Lytle, M.S. Sweet, and J.W. Sweet. 1981. The Chemical and Biological Impact of Klamath Marsh on the Williamson River, Oregon. Report no. WRRI-71. Water Resources Research Institute, Oregon State University. Corvallis Oregon.

Progulske, Donald R.. 1974. *Yellow Ore, Yellow Hair, Yellow Pine*. Bulletin 616, Agricultural Experiment Station. South Dakota State University, Brookings.

Rosgen, Dave. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO.

Salinas, J. 1985. Miller Lake: A Limnological Survey. Report CAS-9502. Winema National Forest, USDA. Klamath Falls, Oregon.

Sherrod, David, Geologist for US Geological Society. 1996. Personnel communications.

Spier, Leslie. 1930. Klamath Ethnography. University of California Publications in American Archaeology and Ethnology, Volume 30.

Steel, William G. 1896. Cascade Range. A National Reservation in This Superb Mountain Region to be Set Apart as a Park, in Establishing and Defending the Cascade Range Forest Reserve: As Found in the Letters of William G. Steel, John B. Waldo, and Others Supplemented by Newspapers, Magazines, and Official Reports 1885-1912, compiled by Gerald W. Williams and Stephen R. Mark in 1995. Crater Lake National Park, Crater Lake, Oregon.

Stern, Theodore. 1966. The Klamath Tribe: A People and Their Reservation. University of Washington Press, Seattle, Washington. 356 p.

Tonsfeldt, Ward. 1987. Mills along the Lakeshore: The Lumber Industry on the Winema Lands 1910-1936. Report prepared under Winema National Forest contract #53-04U3-6-0007. On file Winema National Forest, Klamath Falls, Oregon. 202 p.

Tonsfeldt, Ward. 1995. Reconnaissance and Evaluation of Historic Railroad Systems, Chiloquin and Chemult Ranger Districts, Winema National Forest. Report prepared under Winema National Forest contract #53-04U3-1-00055. On file Winema National Forest, Klamath Falls, Oregon. 264 p.

Troendle, C.A., and M.R. Kaufman. Influence of forests on the hydrology of the subalpine forest. In: Management of Subalpine Forests: Building on 50 Years of Research. USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins Colorado. General Technical Report RM-149.

USDA Forest Service. 1995. Forest Service National Resource Book on American Indian and Alaska Native Relations - Working Draft 1995. USDA Forest Service, Washington DC. p. 76.

USDA Forest Service, PNW. 1983. Guidelines for Sampling some Physical Conditions of Surface Soils. p. 34.

USDA Forest Service. 1990. Land and Resource Management Plan, Winema National Forest.

USDI, BIA. 1930-1947. BIA Grazing Summaries, Klamath Indian Reservation.

USDI, BLM. 1993. Riparian Area Management. Process for Assessing Proper Functioning Condition. Technical Reference 1937-9. p. 51.

USDI, BLM. 1994. Riparian Area Management. Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas. Technical Reference 1737-11.

USGS. 1992. Chemical Analyses of Surface Water Samples in Upper Klamath Basin - Nutrient Assessment Study. Portland, OR.

Volland, Leonard A. 1985. Plant Associations of the Central Oregon Pumice Zone. USDA Forest Service publication R6-ECOL-104-1985.

Wetzel, R.G. 1983. Limnology. Saunders College Publishing. Orlando Florida.

Williams, H. 1942. The Geology of Crater Lake National Park, Oregon. With a Reconnaissance of th Cascade Range Southward to Mount Shasta. Carnegie Institution of Washington Publication 540, Washington D.C.

Whaley, Wayne H. & White, Clayton M. 1994. Trends in Geographic Variation of Cooper's Hawk and Northern Goshawk in North America: A Multivariate Analysis, Volume 5 Number 3, Western Foundation of Vertebrate Zoology.

Winema National Forest Records

Subregional Ecological Assessment Team Report
Forest Recreation records for Head of the River and Jackson Creek Campgrounds
Jack/Mosquito, Panhandle, Hog, Yoss and Skellock, and Upper Williamson River Watershed Analyses

Chiloquin District Records

Deep Creek, Skellock, and Yamsi Allotment Files.

Chemult District Records

Jack Creek Allotment File

APPENDIX

A

Excerpts from Judge John Breckenridge Waldo: Diaries and Letters from the High Cascades of Oregon 1880-1907

These are excerpts from letters and notes written by Judge Waldo on his annual excursions into the Oregon Cascades. The excerpts chosen are those that describe vegetation, aquatic species, fires, etc. In other words, descriptions of reference era conditions. Most of his travels were north and west of here, but he did get down to Mt. Shasta and Crater Lake on occasion. There are literally hundreds of references to deer, and quite a few of bear and elk. Too many to include here so I left them out. I have a copy of the complete manuscript if anyone wants to read it.

Elk Mountain July 30, 1880

"...the broad table ground diversified with park and meadows, forest and open stretches of burnt land, which makes up the summit of Elk Mountain."

"We set our camp near a winding stream of pure cold water among a clump of trees made up of beautiful mountain evergreens. There were the silver firs, the nobilis and the _______, the mountain hemlock, the Engelmanni of spruce, the white pine, Pinus Monticola. There was no disorder about the appearance of their clean cut branches. Trees that stand half the year in this snowy wilderness have the majesty of stern simplicity."

July 31

"Deep River, the course of which we wanted to examine, we found, to our great surprise, to be less than a mile and a half long. The whole stream rises in three or four different channels within that distance and a few hundred yards of each other out of the sand among the black pines in little marshy spots."

"We concluded to camp at the head of the stream I mentioned above where a considerable river bubbles out of the ground with water as pure and cool as can be found. Thence after packing up we came a mile and a half, or little more, to the very source of one of the streams - water right at hand - the finest we have yet had, and better we do not look for."

Crane Lake on Crane Prairie
August 24, 1880

"It led us through the arid sand hills covered with black pine, without water or grass for about five miles, when our eyes sighted from the overlooking higher ground, a yellow expanse of prairie; that looked like a wheat field of several thousand acres in the waste of sand and pine. It was nearly circular, and about two and one-half miles either way - a beautiful spot which answers to Crane Prairie or Lake - it is something of both."

"There is a fresh fire burning on the mountain East of the prairie which makes it very smoky."

Deep River, August 26th

"In the first place Crane Prairie is not easily traversable in any direction, or in a straight line at all. It is traversed by numerous clear canal-like streams - not fordable in the lower part of the prairie where two or more have united. There are numerous swampy spots, beaver land and bogs in the Western portion."

"From high ground upon the mountain, I sighted a stretch of prairie in the Southeast which seemed to be a nook of Crane Prairie (You would appreciate the pertinence of this name if you could hear, as we have, the deep sounding tone of the Sand Hill Cranes, morning and night, and during the day.)"

"Coming down into the sandy black pine forest, or waste .."

August 30th

"The timber here is mostly black pine, with considerable pitch pine in spots - the higher ground generally - some spruce in the swamp, and an occasional fir, as well as willow along the stream and in wet places."

September 8th

"These lakes are about six miles North of our last camp on Deep River from which I wrote August 30th ... The Three Sisters are close at hand..."

"The country around us is extremely barren; no grass except on the Lakes, and no game at our present camp - at least no deer."

Southernmost of the Three Sisters,
September 9th

"He, also, had to tell us of some extraordinary big fish that he had caught today. As the fish are on a string lying in the lake and will be produced at breakfast, I hardly think he can be charged with telling us a fish story."

"There were little mounds of rock on the several summits which seemed to have been piled up by human hands. Adolph found a piece of wood in one, and no timber grows very near the summit. The work, probably, of some superstitious Red Man. There is no timber on the North and East sides of the mountain for a long distance from the summits, but on the South, where we made the ascent, a few straggling white pines are found withing 1500 feet of the summit. They seemed to have little to feed on except rocks and sky. 1500 feet lower down there are great numbers of hemlocks, many of them, seemingly, as old as the hills."

Hot Springs on the Breightenbucher
September 25th

"Forest fires and unexpected obstacles on the line of our march delayed us so that we only made this place yesterday."

Amelia Lake, foot of Mt. Jefferson
July 22, 1881

"We have looked over the Summit and seen the wide fields of Bunch Grass in Wasco County - and not very distant either."

Between Eugene and Crescent Lake
July 30th, 1883

"I heard from a farmer on the road today that the forests on the McKenzie road are burning and giving some interruption to travel."

July 31st

"Fires are burning along the road today. Several trees had fallen lately across the road, all of which, but one, had been cut out - that one, we cut out ourselves, delaying us about three quarters of an hour. The fires are said to be burning ahead, and we may be delayed by fallen timber. It is yet about thirty-seven miles to Crescent Lake."

Big Prairie (Oakridge), August 2nd

"We are camped in what is called the Big Prairie, in the general limits of which Oak trees are found in great numbers. I noticed yesterday, as we drove into the prairie, a high hill or rather mountain on the North side over whose sides oak were scattered increasing into groves at the top. It seems odd to find oak timber so high up on the Cascades. It is not so high as it seems as several families live in the prairie throughout the year. I hardly think that oak is found in the Cascades where the snow lies very deep all winter. This spot of oak timber has probably been spared by the encroaching evergreen forests."

Crescent Lake, August 8th

"It is not so smoky at any time as at home when I left."

Des Schutes, August 10th

"The country is sandy and covered with pine. We can travel almost any distance through it, but water is very scarce."

"The smoke somewhat confounds us in moving along. From the Lake we can prospect ahead and move along in our course."

Davis Lake, August 11th

"The Lake is three miles down to the North East corner and then tends to the Westward further than I can see in this smokey weather. It is lined with "Tule" on the Coast Shore - is full of water fowl - and altogether seems a very considerable lake, excelling anything I have seen."

August 14th

"...I could not see across the Lake to the Northwest on account of the smoke and distance."

"Ed fried twenty-two trout at one time in one of the pans that go with the reflector... He caught a huge trout yesterday - more than an ordinary meal for one person - and says he is going to catch some more of that kind today."

"At the lower end of this Lake there is an immense field of lava almost as barren of vegetation as in the day of its upheaval so many hundred years ago, I should judge. The waters of the lake, in issuing out, flow under this lava for about three miles, and at that distance come out from under the lava in a solid stream, with a noise that can be heard at some distance. The water then flows about three-quarters of a mile into "Deep River" which comes in from the Northwest."

"I saw a flock of wild geese on this river when I visited it the other day, and Mr. Johnson, of the other party, told me that he saw a goose with about 20 goslings at the lower end of the Lake. I had not known before that wild geese bred in Oregon. Water fowl of all kinds are numerous, and fish hawks and white-headed eagles are seen screaming over head."

"The boys came in some time ago with 76 trout, - one that the average fisherman would call a four pounder. They are all cleaned, and we expect to have mountain trout for breakfast."

August 17th

"The boys caught seventy-six trout in one day. We expect to have all we want for sometime as Deep River is a trout stream, and I have even killed one deer. ...The deer here are all what are called Mule Deer."

Under the Lava Beds, three miles
North of Davis Lake. August 18th

"We camped where one body of the lake stream issues from under the lava. All night long the noise of the water as it springs up, evidently from below, on the hydrant principle, sounded like a distant water fall..."

Pamelia Lake, August 4, 1885

"This morning I sauntered along the marshy shores of the upper end of the lake where the soft ground is covered by the tall grass, intersected by several small brooks flowing into the Lake. As I was walking along a log that extends beyond a point of willows which I had just passed, I came in view of two fine buck elk standing among the grass not more than forty yards away."

"The lake in front, the tall bright green grass in which they stood, a fringe of small alders behind them.. "

August 8th

"We are now in Eastern Oregon and the Yellow Pine and handsome larch of the Metolius wave their boughs over us."

Waldo Lake, August 1st, 1888

"Here grows the graceful white pine, tall feathery hemlocks, and mast-like firs (Abies Concolor) with white moss swaying from their branches and curving about their trunks."

September 8th

"The summit of the Cascade Mountains became our highway. Travel soon became delightful over open mossy ridges and flats handsomely dotted with scattering hemlock and pine."

Lake of the Woods,
September 17, 1888

"First day out from Crater Lake we traveled along the summit of the mountains over open grassy ridges and flats sparsely dotted with pine."

"From the summit, a few miles to the Southeast, lay the Lake of the Woods with a yellow strip of prairie of several hundred acres at its North end. ...Pheasants are drumming in the woods, and occasionally a loon is heard on the Lake."

Head Waters of Jenny Creek
September 19th. 12 miles from
Klamath River

"To our surprise we found a wagon road running along on the East side of the Lake of the Woods, which afterward learned runs from near Ashland to Klamath Lake called the Deadington Road."

Grass Valley, near Mt. Shasta
September 27th, 1988

"The mountains here are low and easily traversable and have become from the sheep pasturing parched and desolate. Shasta can only be approached in this direction through a sheep corral, which diminishes sadly its effect. The tumbled down shanties, the odor of sheep, and the desolate camps cannot be separated in the picture from the mountain, grand, snowy, silent."

"There were the clouds almost touching us in the sky above, and here the smoke from the fires on the earth below."

Rigdons Station (Oakridge)
August 27th, 1889

"From Waldo Lake we passed over to O'Dell Lake where there are fish (none at the former), and we are now carrying with us salted lake trout. Tell Ed we caught one 22 3/4 inches in length."

"The trees along the shores of Waldo Lake are chiefly the Mountain Hemlock (Tsuga Pattoniana) and the lovely silver fir (Abies Amabilis). There is also spruce, (Picea Engelmanni) on the mountain sides. White Pine (Pinus Monticola) and the noble fir (Abies Nobilis). This tree with its crown of large upright cones is, probably, the finest looking tree of our high altitude."

Head Waters North Umpqua,
September 3rd, 1889

"Besides, we found the Valley here on fire for miles along the North side... The fire, has, probably, been set out by cattle or sheep men who design bringing stock here for pasturage next year. There have been trappers here, also, who have quite trapped out the beaver..."

"A fire is also raging which has scared the game, and this is no longer the fine camp it was last year."

"Two beaver were in Mr. Johnson's traps this morning. ...The other, the larger one, would weigh, apparently, near fifty pounds. It was three feet eleven inches in length, of which the tail made one foot, and three feet around the body. The curious, hairless, scaly tail was 5 3/4 inches broad in the broadest part."

Head Waters, Middle Fork of the Willamette. September 15th.

"The night before we left the Umpqua our horses came running into Camp, about three o'clock in the morning, and, at the same time, we heard wolves howl down in the meadows where they had been feeding. ...These were the first wolves we have heard, and they but a few moments; though we frequently see their tracks - yesterday I noticed several along the margin of a lonely lake in the woods."

Crescent Lake, September 19, 1889

"I am going over to Waldo Lake this morning - today- to take about a hundred small trout caught here, to put into the lake there. ...We must have the trout growing there to stock the lake when it becomes our Summer Resort."

In camp near the South of Three Sisters. July 25, 1890.

"Thence downward through the black pine and hemlock we filed for about three miles, into the handsome prairie where we are now camped... Such grass for our horses and such a camp for ourselves on the untrodden grass beneath the scattering black pines on the banks of a stream flowing clear and cold over a sandy bottom, and as large as some rivers of classic memory - such a spot we could hardly make but the tent of a night. A few hundred yards above us a green flat of 30 or 40 acres juts up against the side of a steep mountain. Jagged lava rocks and hills of black pine enclosing the other sides, while out from beneath the lava at frequent intervals on the North side, twenty-three springs of pure cold water - some great ones, more of lesser magnitude, bubble noisily over their white bottoms, through the meadow into the main artery which pours down through a miniature canyon and enters our prairie two hundred yards above our camp, there it glides along the side of the prairie between grassy banks, dotted with black pine for more than a quarter of a mile; thence through wooded pine hills for a mile to the Lagoon."

July 26th

"Our prairie was white with frost this morning. The Larkspurs which grow over it were bowing their heads - blue speckled with silver. The dark forest of pine were brightening in the morning light."

The Twin Lakes, Head of West Fork
of Des Chutes; July 27th 1890

"Fresh Lake trout of excellent flavor, as one might suppose of trout caught in the Twin Lakes among these piney forests. Our fisherman was successful as the trout were numerous and unwary, and enough were caught to serve us in our camp of a night."

Trout Lake, July 28th

"Our horses are all tied about our camp to the spruces (Picea Engelmanni) and black pines (Pinus contorta), and the boys are saddling for Waldo Lake."

O'Dell Lake, August 1st

"Some lovely silver firs dispose between and serve as a screen from the wind..."

Summit of O'Dell Peak
August 14th

"From the summit of this peak my eye ranges over a great expanse of forest and of mountain ranges with peaks covered with snow. Mt. Scot and peaks about Crater Lake are seen through the smoky canopy that veils everything beyond in that direction. Nearer, the Cow Horn rises dark and sharp above masses of snow covering the mountain on which it stands on the North. On the East there is a wilderness of low mountains, forest-covered plateaus, with an occasional yellow spot of prairie. The three lakes, Crescent, O'Dell and Davis are distinctively in view. The Three Sisters limit the view on the North what-ever might be seen beyond being obscured by smoke."

Second Camp, Clarks P.O.,
Clackamas County, July 25 1891

"The early morning hours found us driving through beautiful young oak groves, awaiting their fate, condemned to perish at the hands of "The great American Developer"."

Base of Mt. Hood, August 1, 1891

"A few minutes after eight o'clock the homeward bound of the party rolled slowly away down the mountain and soon disappeared behind the mountain hemlocks with which the mountain here is solely covered. No other tree is seen here at the limit of timber."

Metolius Valley, Crook Co.,
August 11, 1891

"And now we have reached our objective point, after a week traversing rocky pine openings, where the wild sunflower grows abundantly beneath the Yellow Pines. Every few miles some fine stream came down from the mountains - a rich strip of green stretching across the black and parched landscape, but as we approached the Southern boundary of the reservation, we no longer found these pleasant streams winding throughout the open valleys. They began to run in deep ravines, impossible to cross except in a few places, or, so far as we know, in any place, except where we crossed them."

O'Dell Lake, August 25th

"The day is not yet far enough along for any breeze to ruffle the lake's surface. Occasionally a fish is heard springing for its insect prey. Now, the clinking sound made by a fishhawk is heard; and, this morning, before I got up, some birds were noisy in the hemlocks over my bed. Now comes the rattle of the kingfisher as he flies low along near the shore. The wall of evergreen forest a mile-and-a-half across the Lake is brightened by the morning sun, and rises in a dense mass to the summit of the ridge that bounds the view in that direction. Now the weird voice of the loon falls upon the ear..."

August 29th

"Last night, we sat evening into twilight and twilight into night under the trees that front the Lake. Thousands of trout flies were flying over the water, and the noise made by the trout at the surface was so incessant and in such numbers that it sounded like the drops of water falling upon the Lake in a heavy rain shower."

September 11th

"He had been out in the sunny spots East of Camp under one of the gigantic firs there, firs standing in the full light of the sun from the ground up, and of such proportions as are never seen with us"

The Three Sisters, September 19th

"We still have fish with us we caught from our boat with the trolling hook at the Twin Lakes... These Lakes are great ones for fish. They are in fact great springs, supplied from the snows of the Three Sisters. Their sources are all underground. The water can be seen bubbling up from the bottom above the shore. They are higher now than they were when we passed down nearly two months ago. The snows have since been melting about the Three Sisters, and is not yet quite gone from their bases."

Lava Beds, Davis River
October 3rd, 1891

"We have ducks in abundance, which Bert gets from Davis River. Also, very fine trout from the same- the trout are not abundant, like the ducks, but we have them nearly every morning for breakfast."

"The trout here in Davis Lake are very fine - the finest we catch anywhere."

October 4th

"We have an excellent camp, in the open yellow and black pine woods on the bank looking down on Davis River where the rushing sound of its water is constantly heard pouring out from under the dark fields of lava which extend Southward and from the North wall of Davis Lake. There is nothing elsewhere resembling one of these lava fields. Their dark, wild, rugged, appearance is a remarkable feature in the landscape."

Otter Point, O'Dell Lake
August 19th, 1892

"Davey killed two eagles yesterday afternoon - one grey, the other a fine white-headed one, with beak and legs of the brightest yellow."

August 21st

"Andrew and Mr. Daley made a fine catch of trout, trolling, yesterday from the canoe. The Lake is unusually clear this year and the trout plentiful and easier to catch than heretofore."

August 28th

"This is the first cougar that has been seen by any of our party, though their tracks are common, and we have seen quite a number within the last few days along deer trails on solitary mountain slopes. It has not been often, hitherto, that we have been along such trails at such early hours and at such distance from camp."

September 5th

"...may bring rain. Andrew says he hopes it will, to put out the fires which are burning around us at some distance, set out by cattle and sheep men to make range. A fine return these gentlemen make for the use of Government Land, free! A fire was burning two or three miles Eastward of the Lake when we first came in, which has been burning ever since and has now nearly reached the Lake, and may burn thousands of acres of timber on the North side of the Lake before it is done.

One day, about 10 days ago, somebody came down on our side of the Lake about a mile above camp and set out a fire. On noticing it, Andrew and I each took a bucket and went up and put it out, after about three hours work."

On the banks of a tributary of a
tributary of the Breitenbush.
August 2nd, 1893

"Mount Jefferson and other familiar peaks were in sight, and a great smoke was seen up the Breitenbush in the neighborhood of the Hot Springs."

"There was a great deal of what I take to be Alaska Cedar growing about the Lake, mixed with Noble, Silver (Abies Nobilis) and other fir."

"This was an airy situation not less than 6500 feet high. The scrubby Alaska Cedar grew, though not the only tree, and we found the dead limbs and trunks made very fine wood."

August 5th

"When three-fourths of the way down we found a forest fire burning which turned us somewhat farther to the left than we intended, but it had not yet spread far enough in this direction to interfere with us seriously."

August 6th

"...a lovely opening in the forest above the river and fragrant with incense cedar. Now it shows the hand of progress and development - handsome cedars cut down and logs lying about. The effect was disfigurement which was only not greater because the improvement had not extended very far. The landscape artist who directed the improvement should receive little employment."

Extracts from an article, entitled "A trip to Mt. Jefferson", by E. L. Massey, and published in the Oregon Weekly Statesman, August 22, 1854

"...affording on the East and North a large body of rich fertile bottom land, and an abundance of grass resembling the Bermuda grass of the Stakopas, Arkansas prairies so renowned for grazing purposes, while the timber will compare with any of its kind in the world; principally cedar and sugar pines."

Rigdons Station, July 25th, 1894

"Mrs. Rigdon called Frank by Hunter's name this morning. Frank corrected her and said he thought he was a better man than his brother; that his brother was a Doctor and killed people, while he was a lawyer and only robbed them!"

Otter Point, O'Dell Lake
August 14th, 1894

"At this time Frank and Bert are out in the canoe fishing. We want to take some with us tomorrow - a treat for Mrs. Rigdon as well as ourselves. They passed around the point where I sit writing a short tome ago, and Frank shouted up to me under my pine tree that they already had a dozen and a half. As one of these fish is frequently a meal or even more for one person, the quantity exceeds what that number of trout usually signifies."

O'Dell Lake, August 14th, 1894

"Davis Lake, which we visited August 1st and 2nd, is all over the meadow lands about it, and even extending into the timber. Our old camp there is now in the Lake, and I had to go quite a distance up the Creek to get above the back water."

August 16th

"This fine lake with its trout and its forests, which yet have not suffered from the ax of the lumberman or other developer of the "resources of this country", we have all to ourselves."

Daley Lake, July 23rd, 1895

"We reached Daley Lake about one o'clock, and the boys caught about fifty fish in a short time. Brook trout."

July 24th

"Rob was not long - probably two hours - in catching fifty one fish.

Waldo Lake, August 8th

"Frank is trimming on the Northeast corner of Inn Point - cutting some Alder trees"

August 11th

"It is very smoky, but a calm, warm day. Cannot see the lower end of the Lake."

August 12th

"...or staid by a fire in the woods Northwest of here, and left there this morning before it was fully light and went down a long, steep ridge looking Northeast into a basin of burnt woods, lying near the foot of a long ridge. The peak burnt on the South side that lies West of the lower end of Waldo Lake."

O'Dell Lake, August 17th

"Either our boys are not expert fishermen or fish are unusually wary or scarce, for we have had but one mess thus far."

Rigdons Station, August 18th

"The air, however, is quite full of smoke. Some of this comes from a sheep man's fire North of Waldo Lake, but this fire would hardly account for the quantity everywhere prevailing."

O'Dell Lake, September 5th

"Dan may be interested to know that there are no more eagles about Eagle Bay. They have abandoned this point, but some are still to be seen about the Lake. Fish Hawks frequent Trappers Bay, and occasionally our Bay. Davey Smith does all the fishing, and by industry and perseverance keeps more than a supply on hand. He has a fine lot to take to Mrs. Rigdon tomorrow."

"A mountain Ash stands half way down the bluff-like point of Otter Point, which is so heavily loaded with red berries that the tree seems on the verge of withering away. I noticed just now a bird come and pick at the berries. Tassel Wood, also, grows here, the leaves of which have a fragrant smell. This is a characteristic of all the Tassel Wood growing in this part of the mountains. White Gulls from the Sea are here. This must be their Outing or Summer Resort."

Rigdons Station, August 23rd, 1896

"We came back by Diamond Lake through the North Umpqua country where we made many fine camps in other years, but found that the sheep men had taken possession of the country. The beautiful meadows on the North Umpqua were completely ravaged."

"I have come in here today direct from Crater Lake by way of Diamond Lake and the North Umpqua - a route with which Dan is familiar, but not with the sheep trails with which that country is now traversed. There is a plain blazed trail from Diamond Lake to our old camp on the North Umpqua, and the grassy meadows along the Umpqua look like they had been struck by a cyclone - the sheep having laid all the grass flat to the ground that they have not eaten."

"There are two thousand head of sheep at Diamond Lake."

"The whole country was covered with smoke - so much so that we could not get a clear view, even of the lake, in a little over a day that we were there."

O'Dell Lake, September 4th, 1896

"No new thoughts in this walk; too smoky to see any considerable distance. Large trout have begun to come into the Creek, we discover."

Daley Lake, September 24th

"This Lake is well stocked with fine mountain trout. A Fish Hawk or two were diving after fish into the Lake this morning, but they are now no longer about the Lake."

Daley Lake, September 14, 1898

"I came along afoot with the ax, and am now going back to camp leaving the boys to fish. They have thus far caught about seventeen."

September 15th

"Mac and I took a tramp to some peaks Southwest of Camp. There was considerable Alaska Cedar growing on the sharp ridges - small trees - the tallest not over thirty feet high."

"Also saw a small lake North of the peak and North of Daley Stream, which we visited; found a small stream flowing out, and a little water on the South side coming in - rather seeping than flowing. The water of the Lake very warm and rather stagnant. There were many Water Dogs in it, but no fish that we saw. There were fresh beaver signs about it, and a family of beavers evidently make their home there."

September 23rd

"I have noticed three varieties of cedar growing in this vicinity: Alaska Cedar, Rough Bark Cedar, the common Valley cedar; also the two varieties of hemlock, white and black, but no yellow or sugar pine. Douglas Fir; nobilis, silver and Amabilis fir, and the downy cone fir, very likely "

"We noticed that the forest fires that were burning the other day, West of Independence Valley, and Northwest of Trident Peak, had been put out, but a smoke was rising, if it were smoke, down the valley of the South Santiam, as seemed."

September 24th

"The boys caught 192 fish."

Don Smith's, Gates, Oregon
August 13th, 1900

"Here I am, after the lapse of so many years, sitting on the bank of the Santiam at our old crossing. Then the freshness of an almost untrodden wilderness was around me; now, one hears the rattle of wagons, and sees the evidences of habitation on every hand. Even the river has a tamer look. How altered - not only the scene, but the thought and feeling of the beholder.

I am not now entering upon new adventure."

Fish Lake, July 13th 1901

"Fish Lake is quite a lake. In September 1898 it was a sheep pasture with very little water any where in its bed. There was a small creek on the Fish Lake House side out of which we got water for ourselves and horses. It was very nearly all the water in Fish Lake at that time."

Lost Lake, July 18th, 1901

"Lost Lake has been visited since, as the remains of camp fires show, but not often. The Lake is higher than I have seen it before. As it fills up the water probably tends to rise, and there is a great deal of sand washed into it in the Spring, which must fill it up before a great many years."

Hensley Meadows, July 19th

"The scene is not quite the same, nor, I suppose, am I the same, but nature's changes are usually pleasing, though, doubtless, we sometimes wish the young pines had made less growth and the old ones showed less signs of decay."

July 21st

"Hesseman says there is a species of lake trout in Marion Lake different from the river trout below, with which the lake was stocked some years ago, and which he thinks were not put in by white people at least and which the Indians claim were there long before the whites came."

Elk Lake, Marion Co. August 21st

"We had fish the first night, a present; and Mr. Croner has since caught all we wanted. He made a fine catch yesterday - large, fine trout out of the Lake. The rangers have a raft from which the fishing is done."

"The rangers have a very comfortable cabin, without a floor, with a large, cavernous fireplace, and bunks against the opposite wall for beds. They get plenty of fish, but found deer quite scarce. The wolves seem to be getting somewhat plentiful in the mountains again, having killed a good many cattle about Elk Horn last winter, and this may partly account for the scarcity of deer."

August 30th

"There are great quantities of huckleberries and blackberries in the burnt timber North and West of camp."

Belknap Springs, August 2nd, 1902

"There are numerous bottoms along the river covered with Douglas Fir and Cedar, mostly of a growth less than one hundred years old. Sometime within that period the ground has been swept by fire which only a few old trees escaped. The reseeding has been gradual, and the ground is now so thickly covered with Salal bushes that it is probably hard for trees to get a start."

Lower Fall of the McKenzie,
August 6th, 1902

"It is eight minutes of Twelve o'clock and John has just caught the first fish right by the falls. A large one I could see.. I saw a King Fisher fly along, going down stream."

"We found no fish between the falls, although there are fish in Clear Lake above and in the river below. The only still reaches of water in the whole river seem to be between the Middle and Lower Falls, where the river widens out into small lake-like reaches which not only have been but are now the home of beaver. Fish cannot get up from below, but I should think they would occasionally come over the Falls form above. If there are any at all, they must be few or we would have seen some. J. A. Smith who tried for fish here last year says he found none.

There are two forest fires in the vicinity of Hoover's. I have been at Belknap Springs for something over two weeks and have seen one and learned of another in the neighborhood of the Springs, but found no ranger anywhere within call, so I will drop a line concerning these fires to the chief forest ranger of this district. One of them is up the river about eight miles above the Springs below the mouth of Olalla Creek. A couple of rangers with their shovels and axes could have put this fire out in a half a day or less. It is in a bottom covered with fine cedar and fir timber and may easily do enormous damage. The other is said to be about six miles in the mountains Northwest of the Springs."

Hensley's Meadow, August 30,1903

"Our first fish we had at Independence, and we ate 104 at three meals. Not large, but very fine, mountain trout. Friday we caught 57 here, and ate them at two meals. ...Later - our fishermen brought in 129 trout."

"The temperature of the water here is 41 degrees - cold enough."

September 3rd

"I hear of no forest fires this year. The rangers are having a good time. The Ranger, Lacy, is again at Fish Lake this year. The sheep are everywhere and spoil the mountain pastures for campers. Many thousand are in the mountains this year, above the number last year, I suppose, from the new flocks I hear of. I trust they will keep clear of Waldo Lake, next year."

"250 trout is the number caught within the last two days; but for venison we have had none except a piece given us by a camp near by."

"I walked over to Daley Lake and back... I found there had been no campers there this year, but the sheep are nearby, and I found the sheep men's horses at our former camp, about a mile and a half this side. I saw many trout swimming in the Lake..."

North end of the large lake at the
Southwestern base of Olalla Butte.
August 20th, 1904

"David, George and I went to the top of Olalla Butte this morning. About two hours and twenty minutes making the climb. A double peak 125 yards apart with a slight bare depression between them.

The Government Signal Monument is on the North peak. And here on the Northeastern slope is a large patch of snow. There are some scrubby mountain hemlocks on the extreme summit. (Pinus Albicaulis)

There is one lake several hundred yards lying North, and about fifteen in sight on the South. It is a region of lakes, all, apparently, without any outlet. But it was too smoky to have any extended view. The predominant trees are lodgepole pine."

Hot Springs of the Clackamas
August 12th, 1904

"The water is not as hot as the Belknap, and shows no indications of sulphur or salt. It feels to the hands, when cold, exactly like water in which borax has been dissolved. So it is very fine for washing No soap is needed."

"David came in about half an hour ago with 45 fish. George, who did not fish very long, got eight They are small fish, and I guess we can eat nearly all of them for breakfast."

Heideck's Cabin, Two and one-half miles below Pamela Lake. August 9, 1905

"The boys caught forty nine trout at the Lake which we will have for breakfast soon."

August 13th

"This Lake has not near so much water as it had in my earlier camping days, for until last year I had not been here for seventeen years -... but it still has abundant and fine fish, and we have not only caught all we wanted to eat, but Mr. Downing has the surplus catch on a framer drying."

August 24th

"Mr. Downing caught about seventy fish yesterday. The boys got back after dark from their Marion Lake trip. They found no one at the Lake, and did not stay to fish. Enterprise does not distinguish them."

Pamela Lake, August 29th

"Earl has just come in from the lake and says they caught 72 fish..."

September 2nd

"Still very smoky and seemingly cloudy, but this appearance may be produced by the dense smoke."

September 3rd

"The mountains are covered with smoke. I can see the burnt ridges beyond Unknown Prairie, and as far as Bachelor Mountains in the West."

"About three miles from the Cabin to the West side of Grizzly Flat, I met Henness and Anderson, head ranger in Grizzly Flat, on their way to the fire on the waters flowing from Jefferson into the Metolius The cabin is located near some large concolor fir trees."

South Bank Santiam River on the
point above the bridge at Gates.
August 16, 1906

"The years roll away and here I am again on my way to the mountains. The almost unbroken wilderness is no longer here. The changes made only by time are probably not very great. The river still flows as of old, and the noise of its rushing waters must be the same, but the waters do not issue out of the old unbroken solitudes and hence there is something missing."

Quartzville, August 18th

"William Clark tells me a fir tree fifteen feet in diameter is to be found in this section."

Daley Lake, August 31st

"The fishing continues very fine, and we have more trout on hand than we can use for supper and breakfast, although we have fished none today."

September 1st

"Dense smoke, West and North of it, indicated that the fire was burning across the divide, or rather up McKinney Creek, not far Northwest of the mountain."

Pamelia Lake, August 14, 1907

"This time we find many campers at the Lake; its excellent fish, and nearness to Mt. Jefferson are its attractions."

Gatschet, Albert S. 1890. The Klamath Indians of southwestern Oregon. Government Printing Office, Washington, DC. P. Xxiii

Excerpt from Annual Report of Chief Engineers, Lt. Wheeler, 1878.

"The further we recede from the Cascade Range and its more humid atmosphere the less vegetation is developed. The lake shores and river banks, when not marshy, produce the cottonwood tree and several species of willows, and the hills are covered with the yellow or pitch pine and the less frequent western cedar. In the western tracts of the Reservation large tracts are timbered with pitch pine, which seems to thrive exceedingly well upon the volcanic sands and detritus of the hilly region. These pines are about one hundred feet in height, have a brownish-yellow, very coarse bark, and branch out into limbs at a considerable height above the ground. They stand at intervals of twenty to fifty feet from each other, and are free from manzanita bushes and other under growth except at the border of the forest, leaving plenty of space for the passage of wagons almost everywhere. A smaller pine species, Pinus contorta, which forms denser thickets near the water, is peeled by the Indians to a height of twenty feet when the sap is ascending, in the spring of the year, to use the fiber bark for food. Up high in the Cascade Range, in the midst of yellow pines, grows a conifera of taller dimensions, the sugar-pine. The hemlock or white pine, the juniper, and the mountain mahogany are found in and south of Sprague River Valley."

Examples of Current vs. Reference Era Stand Conditions in the Williamson Watershed

[illegible] 2.—Excellent pole and sapling reproduction of ponderosa and sugar pine on Solomon Butte in 1956. This area was [illegible] logged about 1927 or 1928 and was burned by the [illegible] fire.

Fig. 1.—The 1918 fire burned over this area on Calimus Butte, photographed by the writer in 1930.

APPENDIX

B

SUMMARY OF SOIL COMPACTION RESULTING FROM SITE TREATMENTS

Plot Name	CB2A	BR1	GL5	Merrit 23*	Merrit 22	Collier IC	Collier IIC
Location	T33SR08E Section 7	T33SR08E Section 8	T33SR08E Section 17	T34SR07E Section 33	T34SR07E Section 32	T34SR07E Section 16	T34SR07E Section16
Area (acres)	152	34	63	22	17	38	76
Soil Type	A4B4	A5B5	A4B4	A8**	B4A8**	H6	B4H5
Histo ical Treatments	Mower ?	Tomahawk 2 or 3 treatments since burn	Mower 2 or 3 treatments since burn	Logged early 80's Machine piled (93) Machine Planted (94)	Logged early 80's Machine piled (93) Machine Planted (94)	Crushed (79) Machine Planted (94)	Slashbusted (95) Machine Planted (95)
Reference Bulk Density (g/cm^3)	0.5	0.56	0.55	0.61	0.61	0.51	0.51
% Unit Area Over 20% Compaction	18	23	10	43	16	30	32
Exceeds Standards?	no	yes	no	yes	no	yes	yes

* This site was used as a landing after it was logged

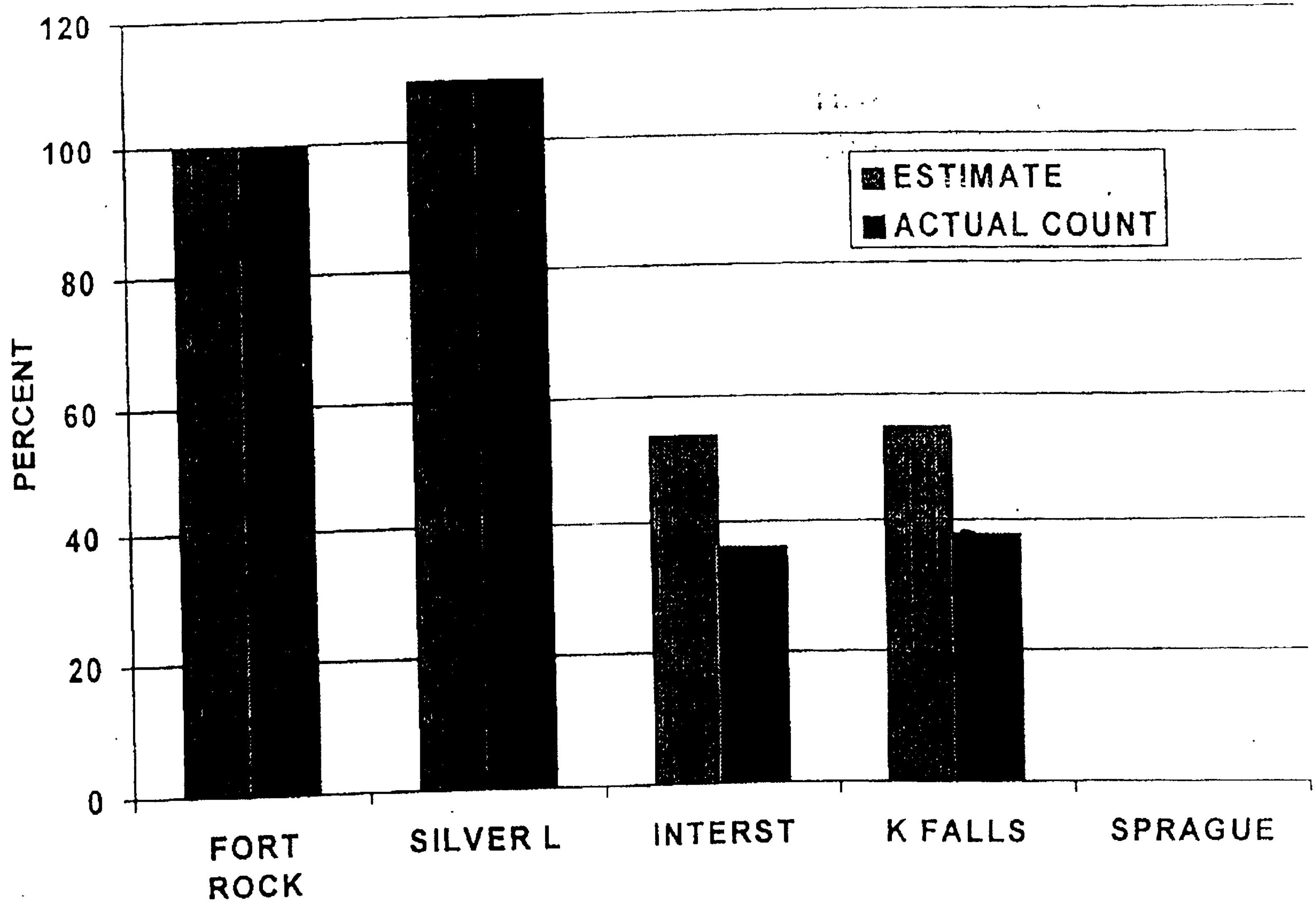
** Although these are the soil types found in the SRI for these units, there appears to be "H" and "G" soils in portions of these units.

APPENDIX

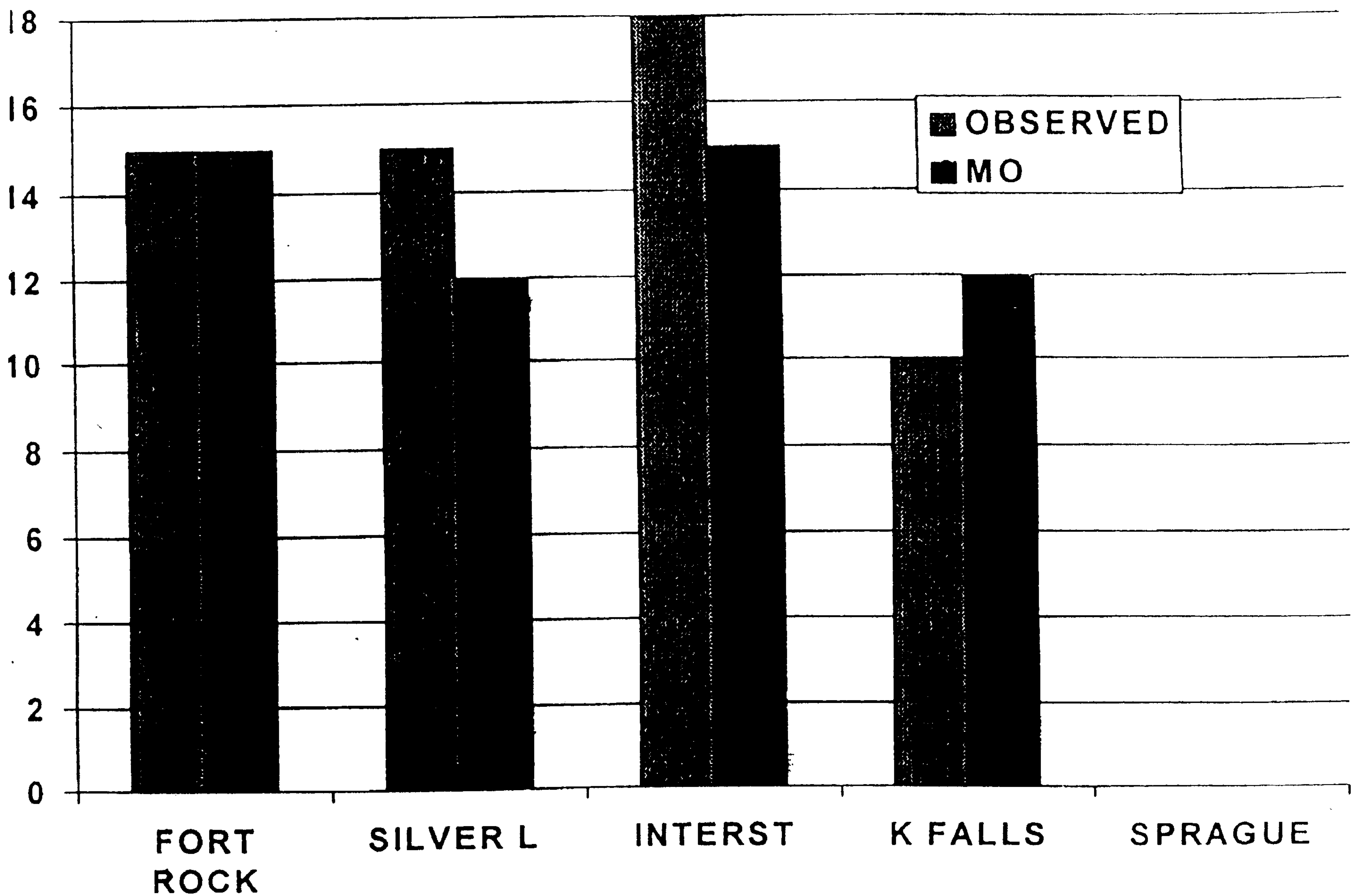
C

The following graphs were provided by Craig Bienz, Klamath Tribes biologist.

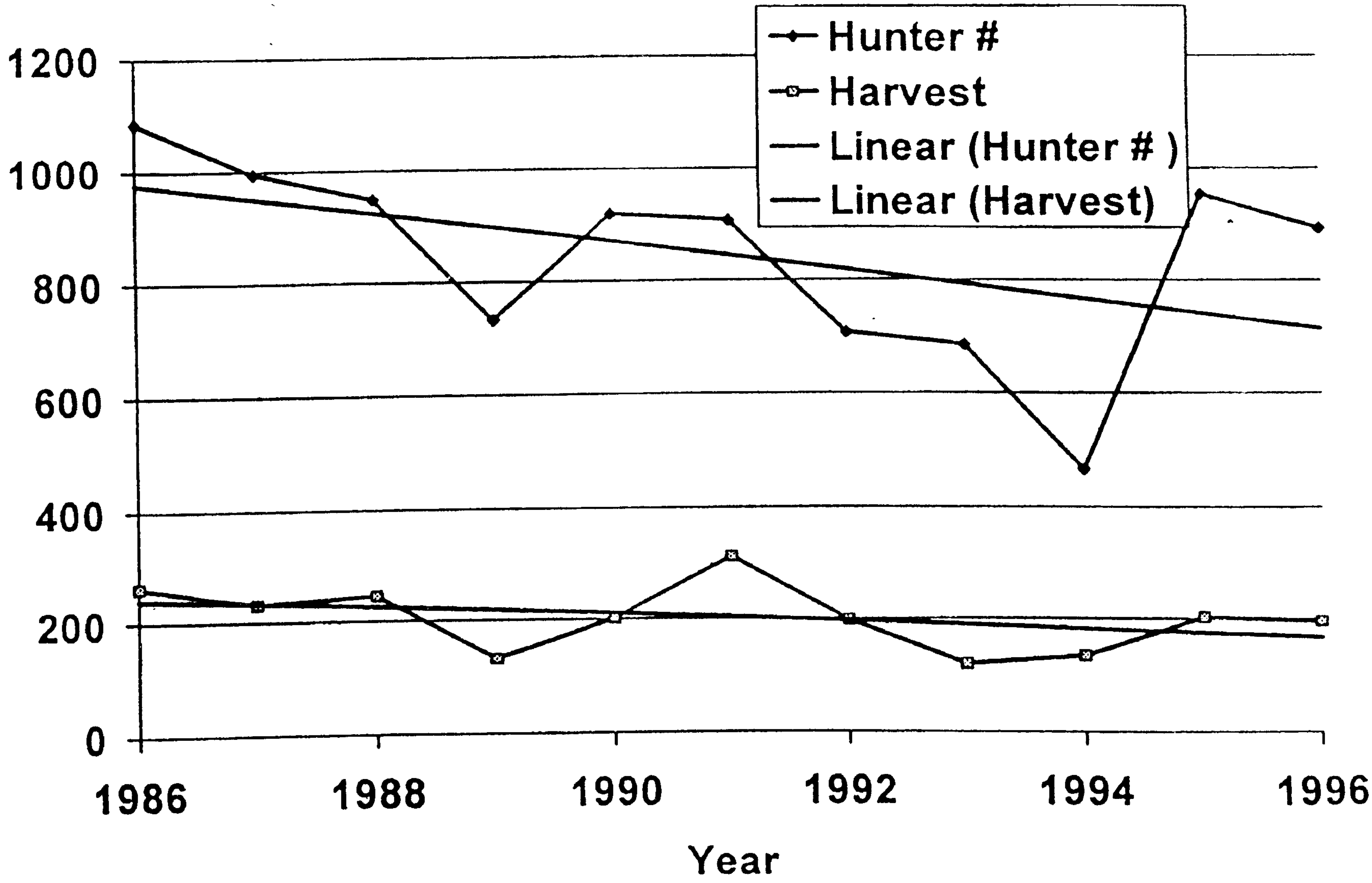
ESTIMATED MULE DEER POPULATION RELATIVE TO MO (%), 1997

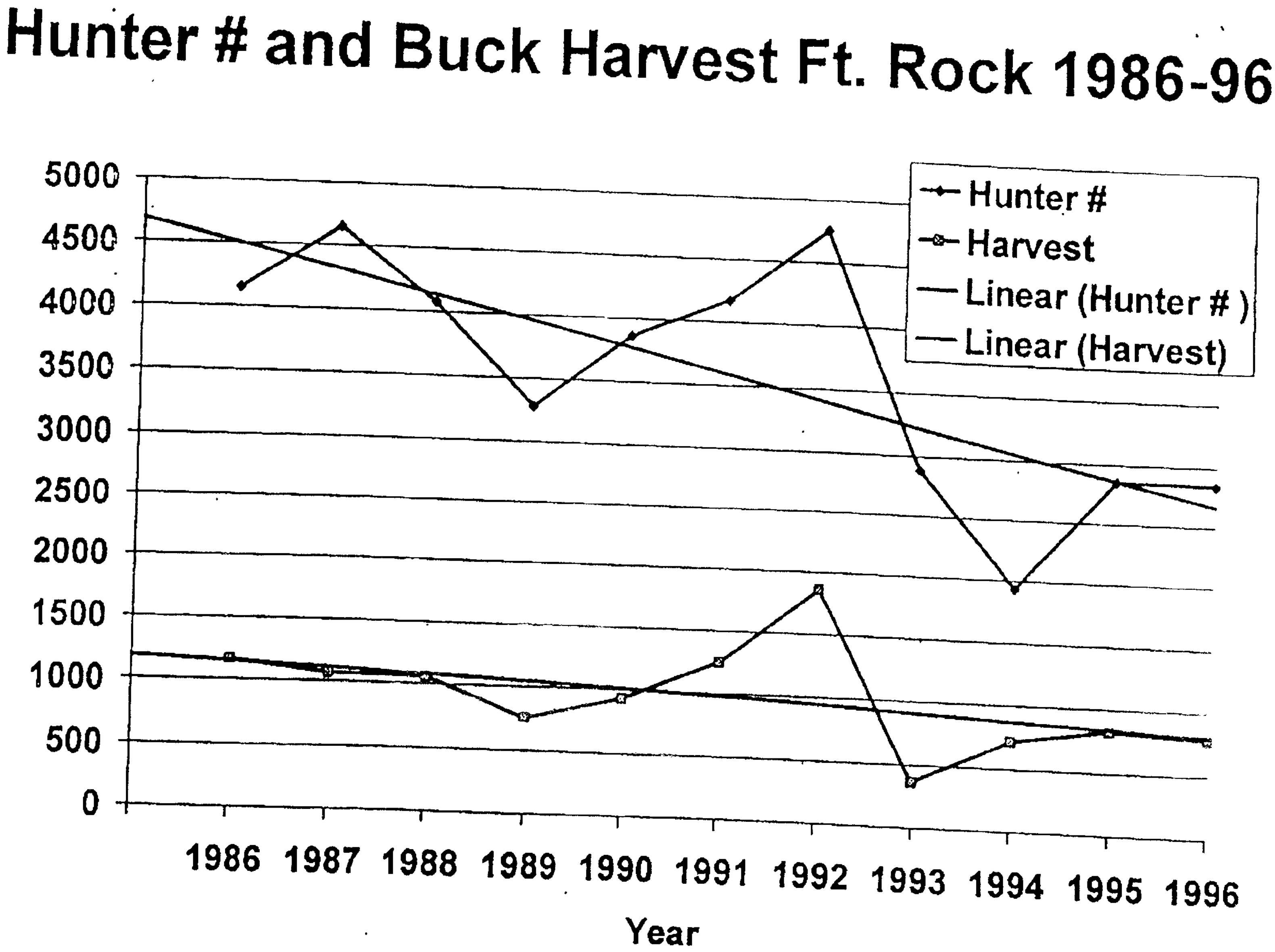


MULE DEER BUCK RATIO (3-YR AVE) RELATIVE TO MO, 1997

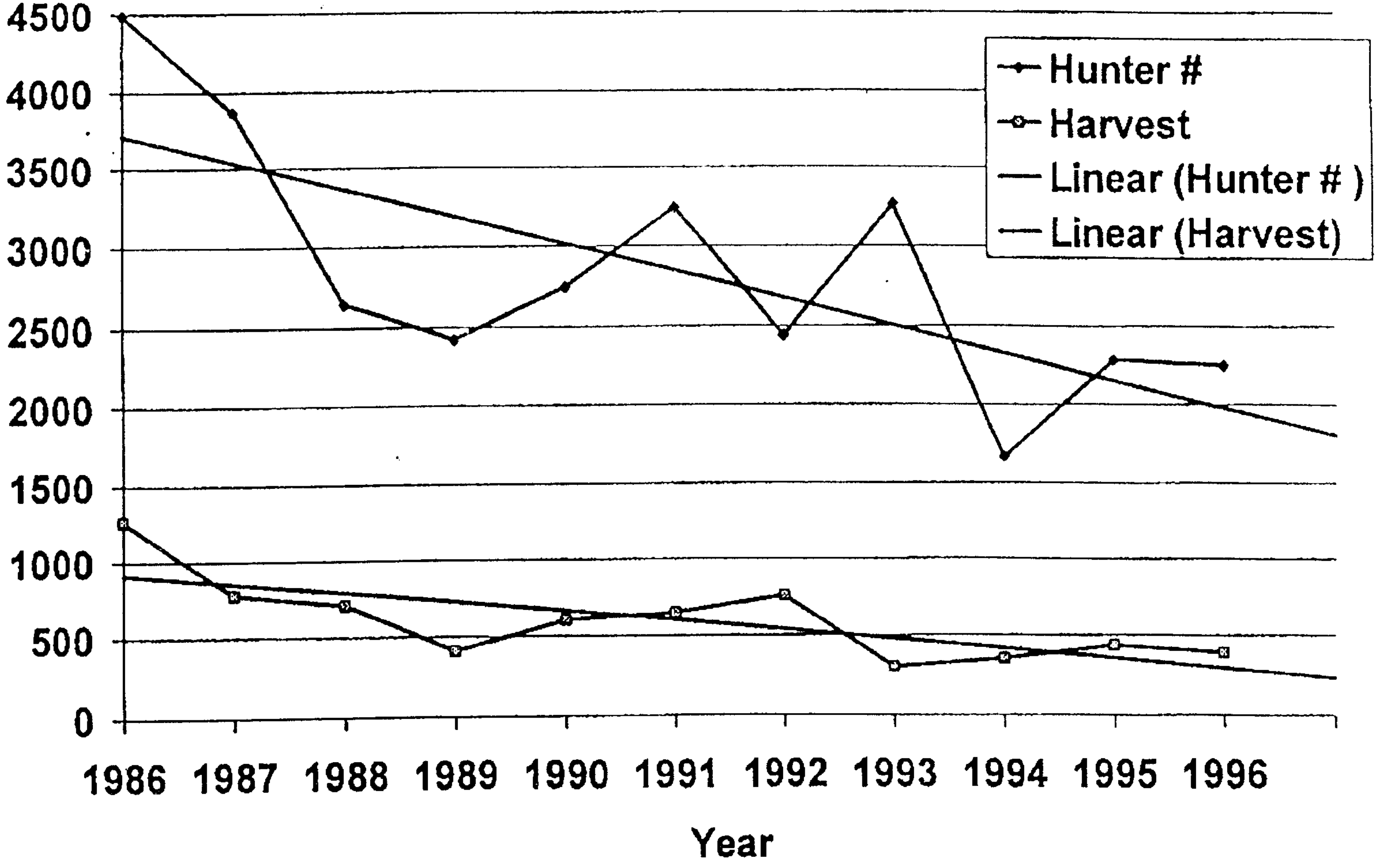


lunter # and Buck Harvest Sprague 1986-96

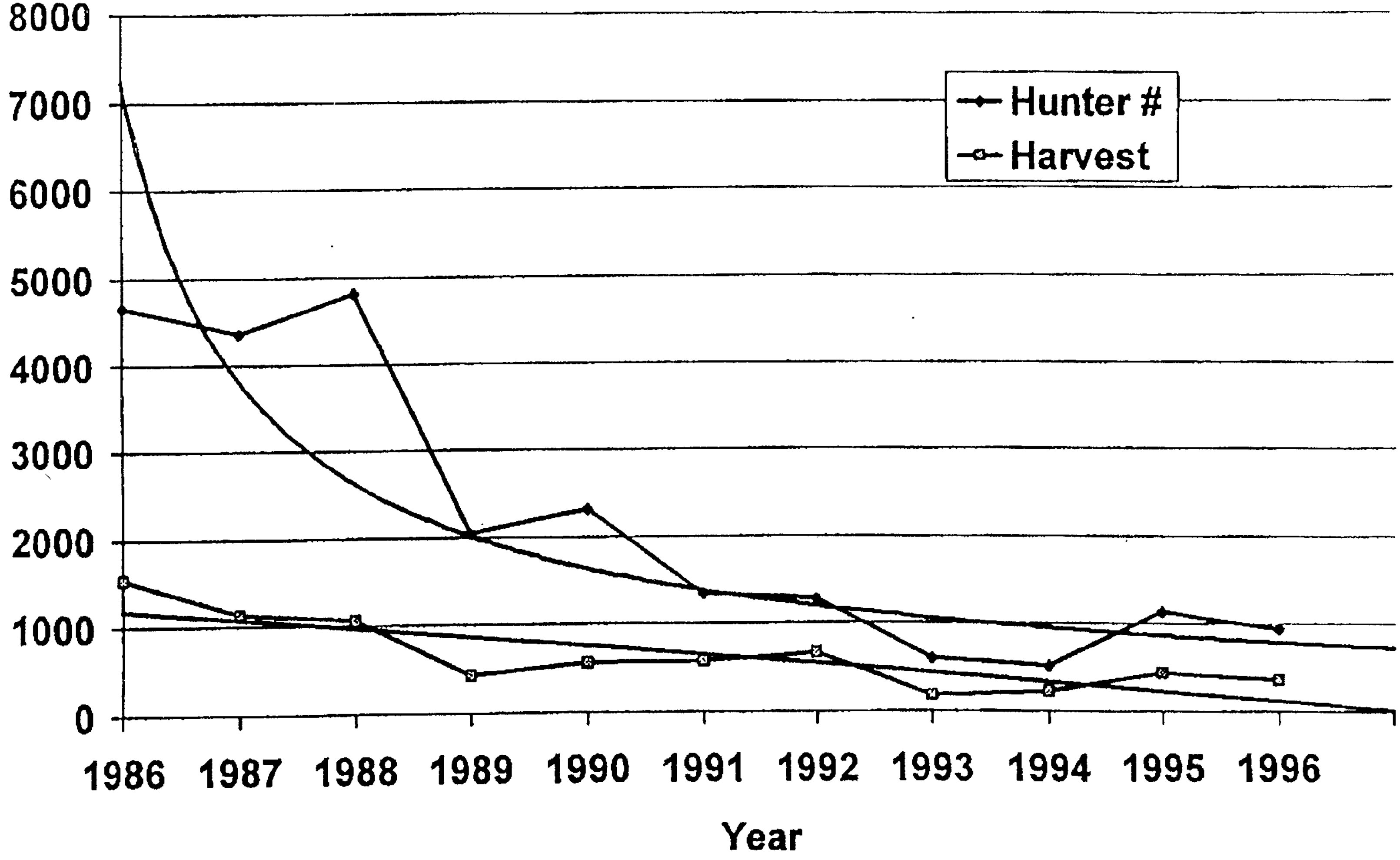



Hunter # and Buck Harvest Ft. Rock 1986-96
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Hunter #
Harvest
Linear (Hunter #)
Linear (Harvest)
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year

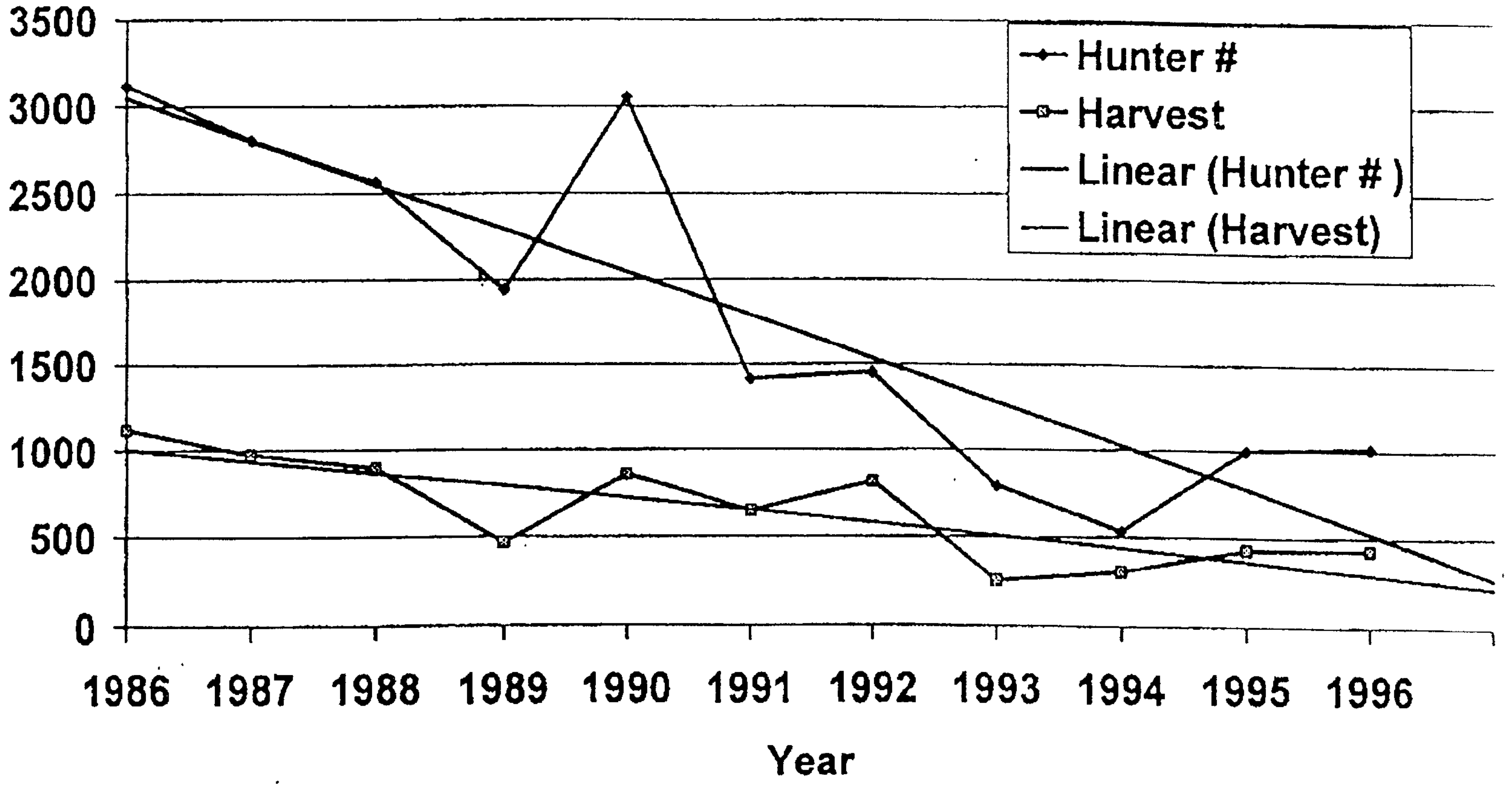
Hunter # and Buck Harvest Silver Lake 1986-96

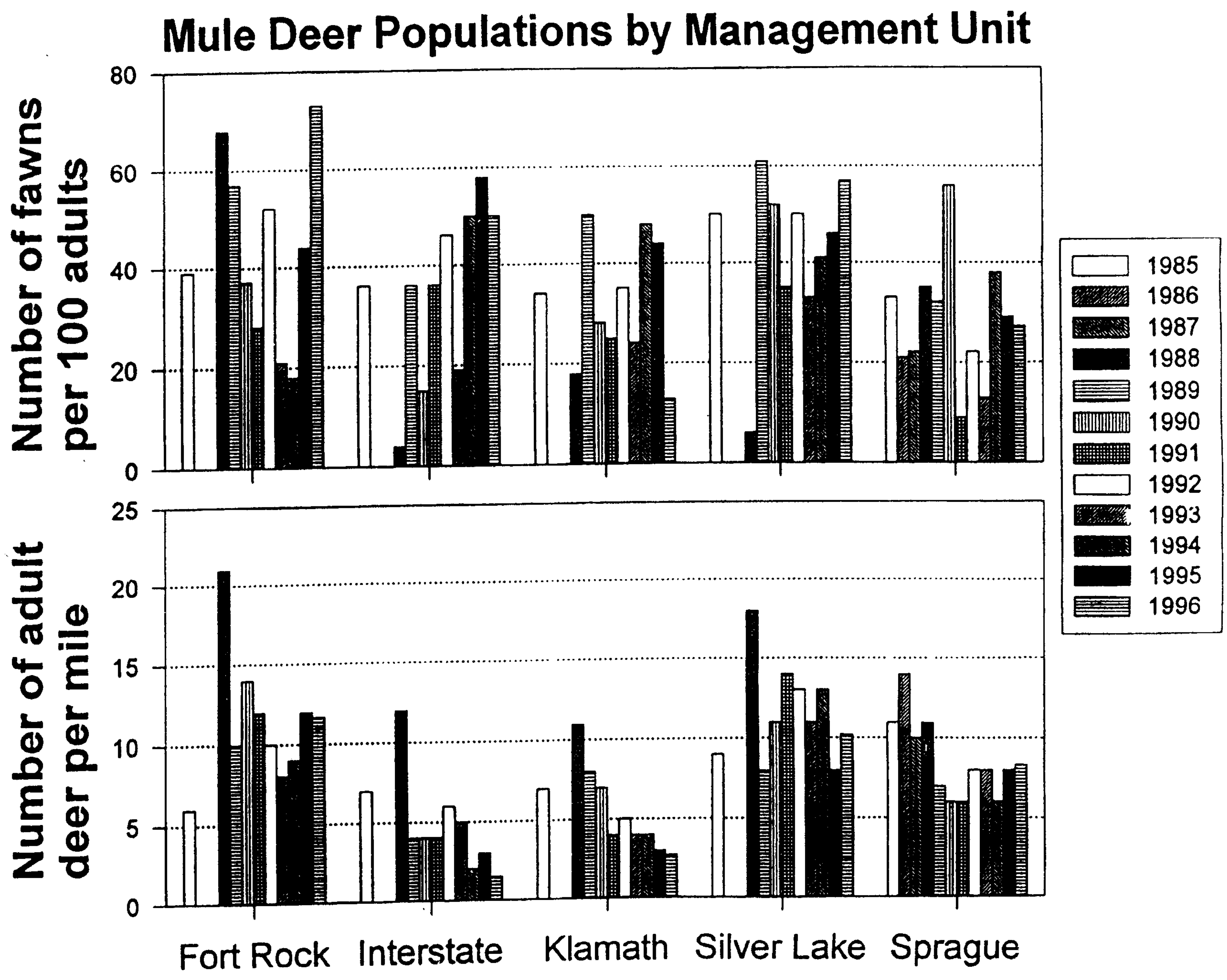


Hunter # and Buck Harvest Klamath Falls 1986-96

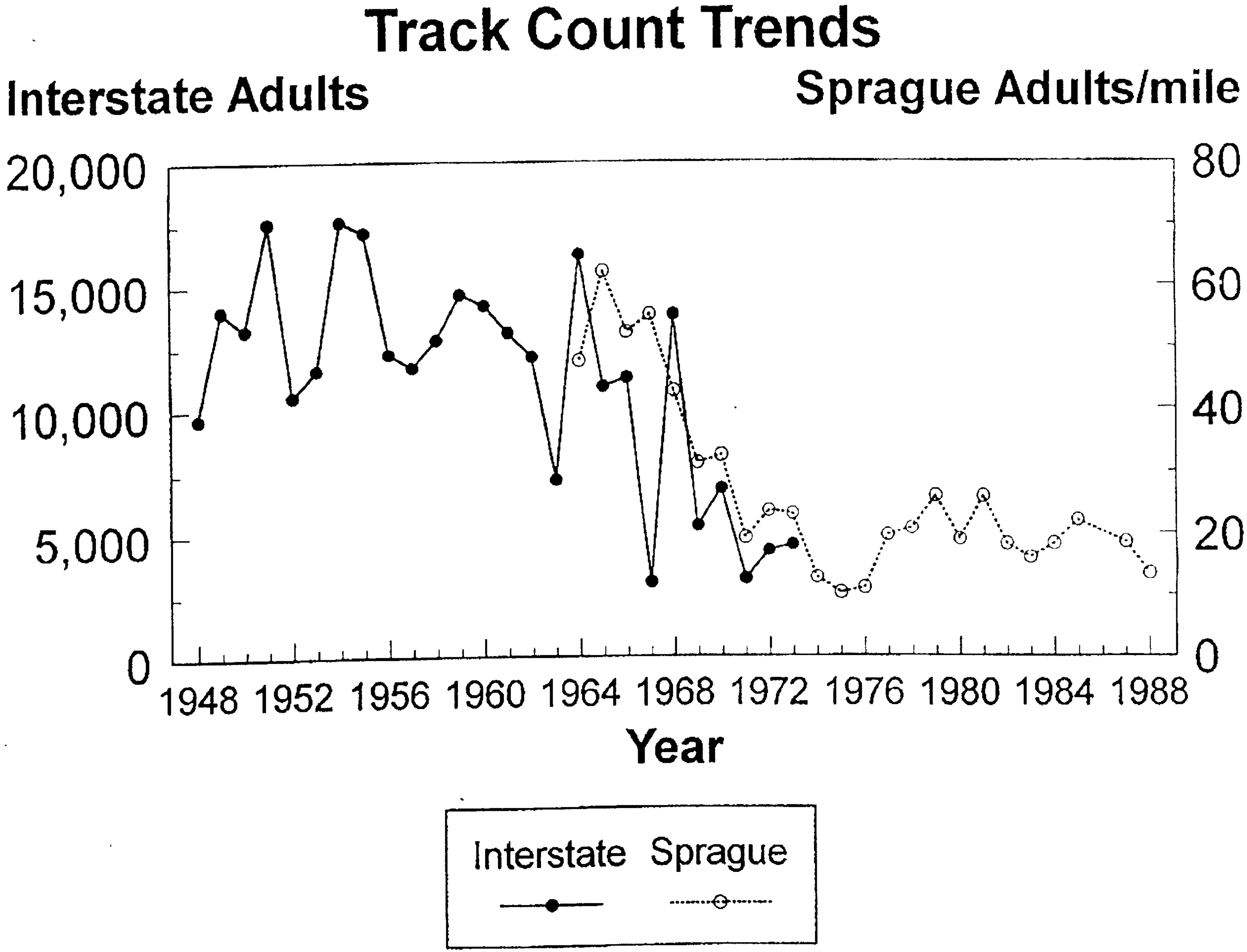


Hunter # and Buck Harvest Interstate 1986-96

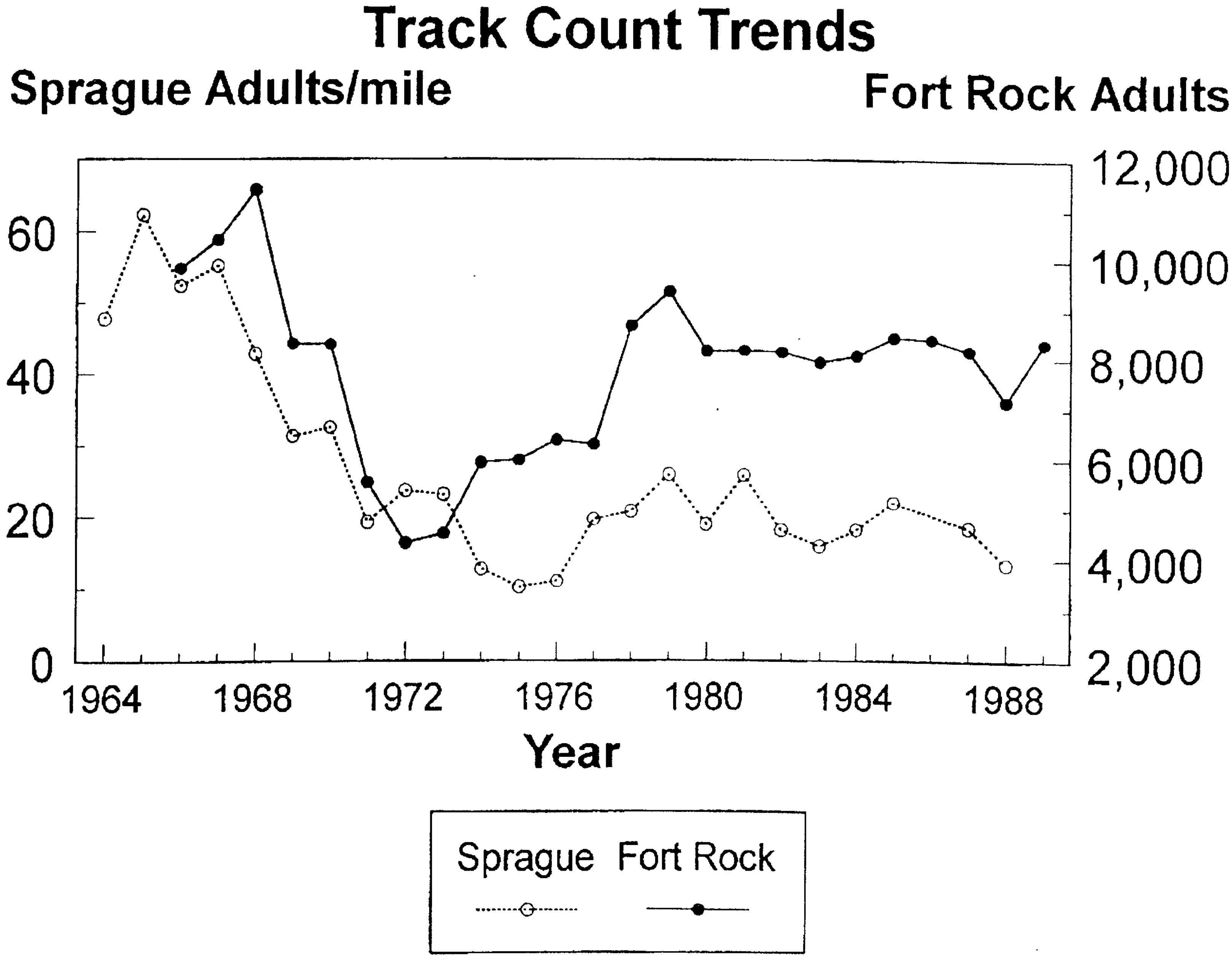


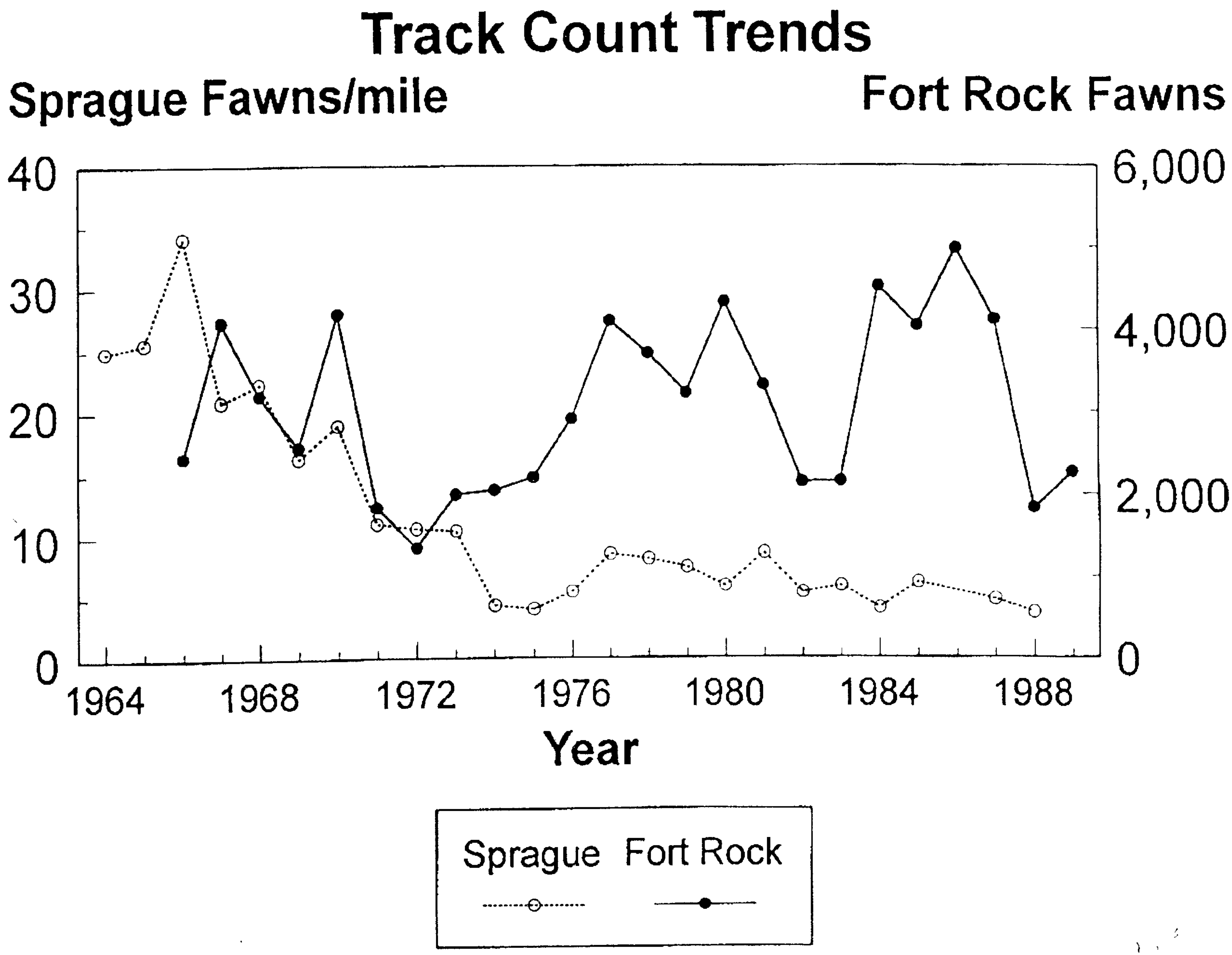


Mule Deer Populations by Management Unit
Number of fawns per 100 adults
Number of adult deer per mile
0
20
40
60
80
0
5
10
15
20
25
Fort Rock
Interstate
Klamath
Silver Lake
Sprague
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996

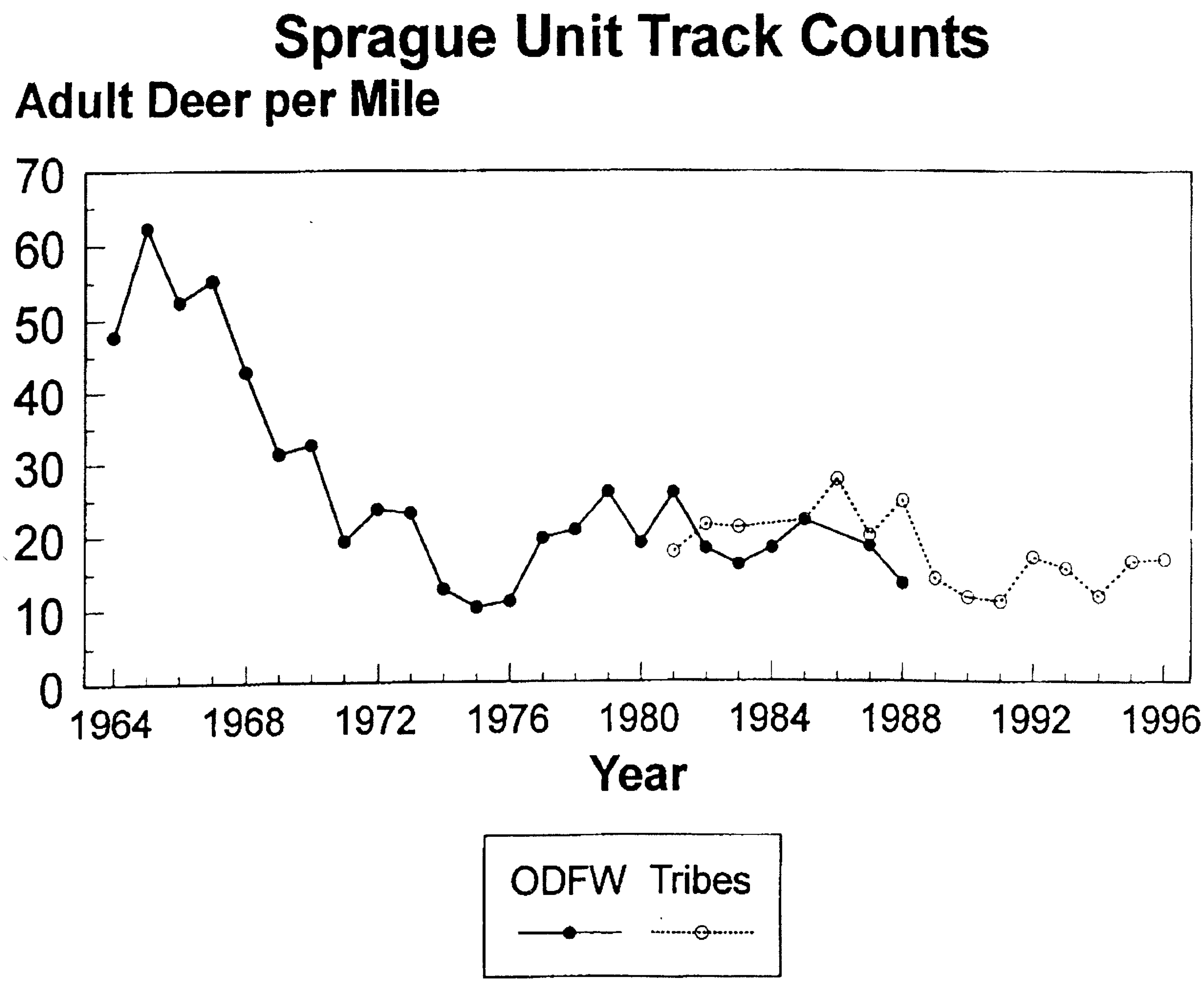


Track Count Trends
Interstate Adults
Sprague Adults/mile
20,000
15,000
10,000
5,000
0
80
60
40
20
0
1948 1952 1956 1960 1964 1968 1972 1976 1980 1984 1988
Year
Interstate
Sprague

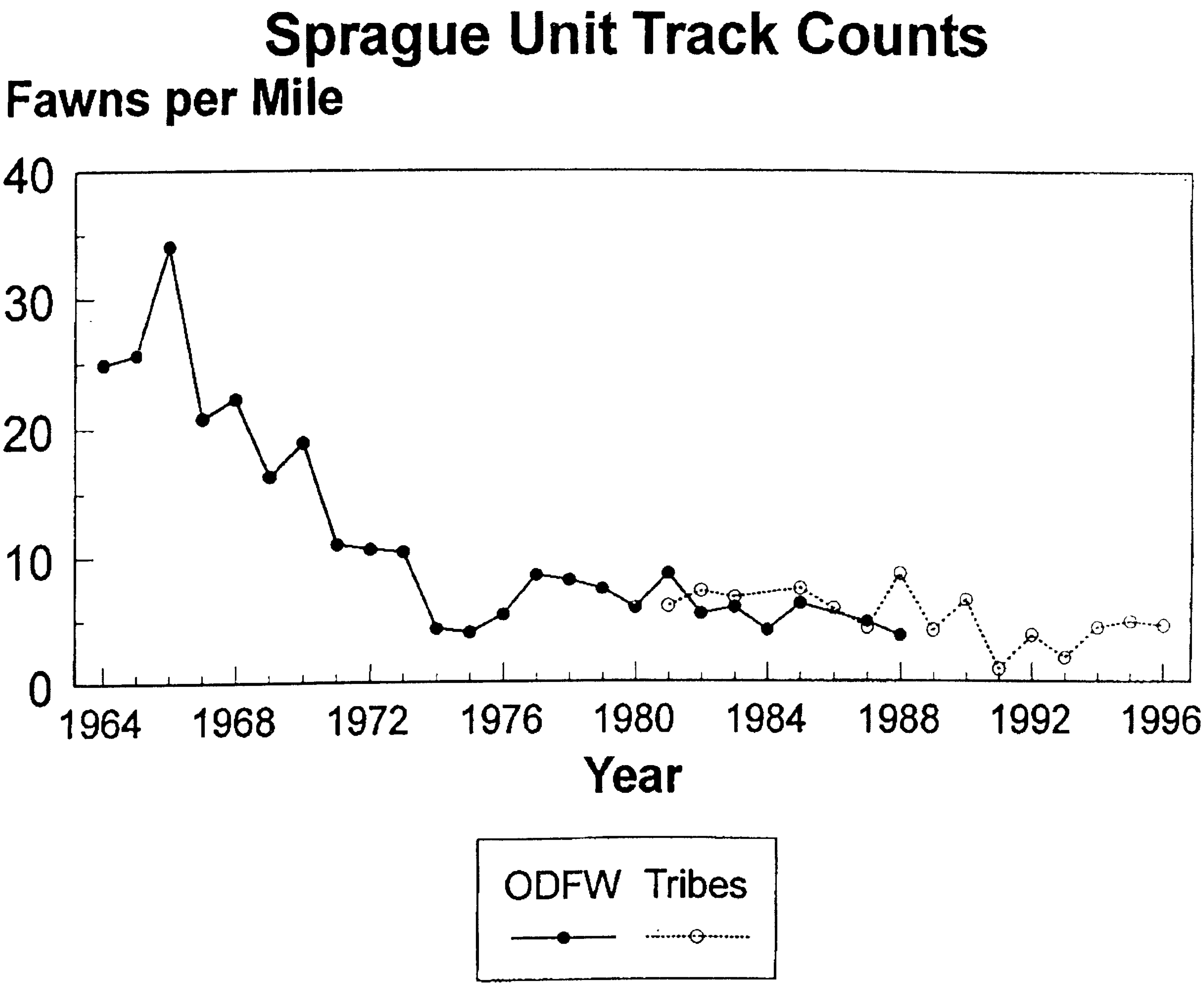

Track Count Trends
Sprague Adults/mile
Fort Rock Adults
60
40
20
0
12,000
10,000
8,000
6,000
4,000
2,000
1964
1968
1972
1976
1980
1984
1988
Year
Sprague
Fort Rock



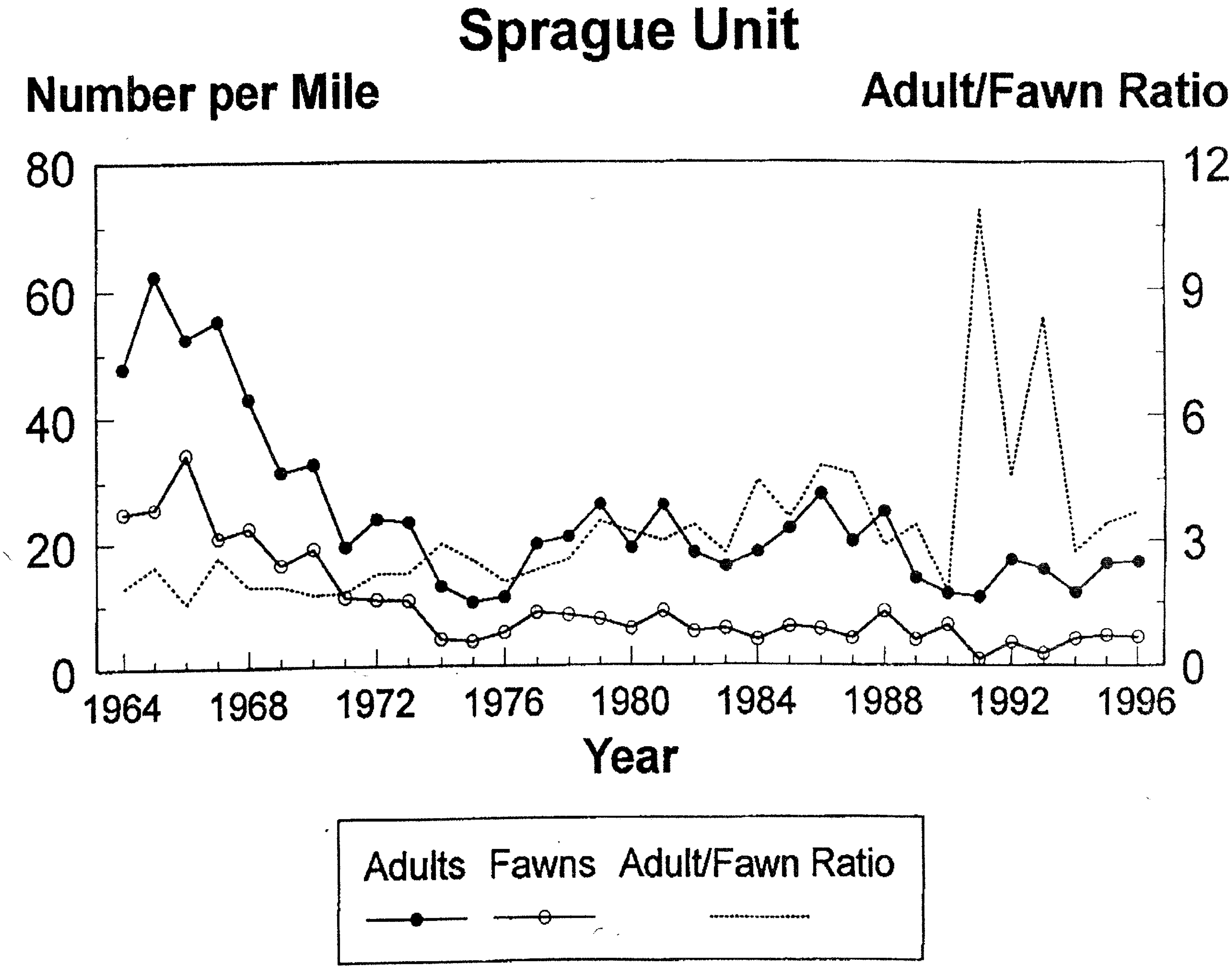
Track Count Trends
Sprague Fawns/mile
Fort Rock Fawns
40
30
20
10
0
6,000
4,000
2,000
0
1964
1968
1972
1976
1980
1984
1988
Year
Sprague
Fort Rock



Sprague Unit Track Counts
Adult Deer per Mile
70
60
50
40
30
20
10
0
1964
1968
1972
1976
1980
1984
1988
1992
1996
Year
ODFW
Tribes

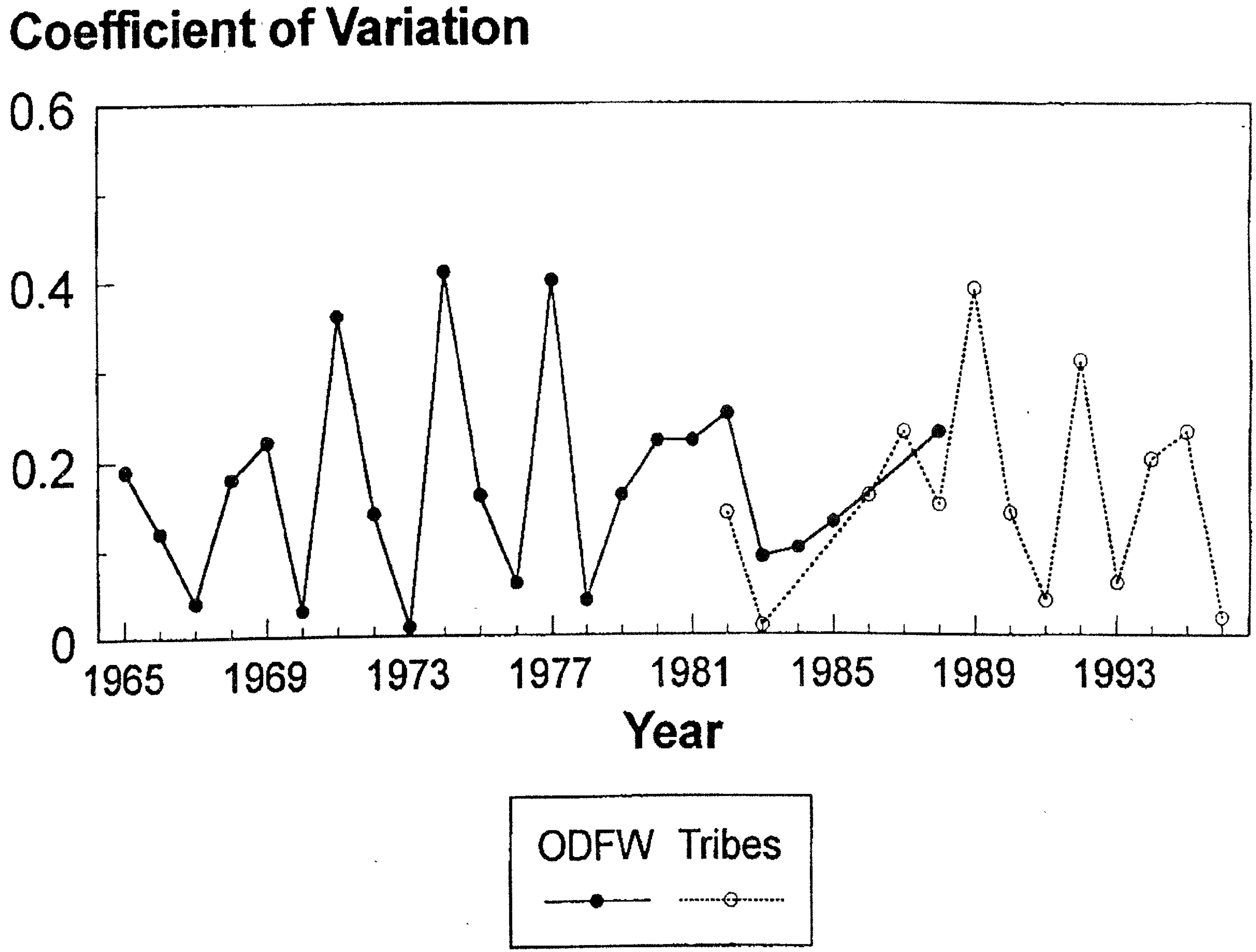


Sprague Unit Track Counts
Fawns per Mile
40
30
20
10
0
1964
1968
1972
1976
1980
1984
1988
1992
1996
Year
ODFW
Tribes



Sprague Unit
Number per Mile
Adult/Fawn Ratio
80
60
40
20
0
12
9
6
3
0
1964
1968
1972
1976
1980
1984
1988
1992
1996
Year
Adults
Fawns
Adult/Fawn Ratio

Adult Track Count Variability



Note: Coefficient of variation is calculated on a two year running average of adult deer per mile.

APPENDIX

D

FUNCTIONAL CONDITION AND PERIODICITY OF CHANNELS IN THE HEADWATERS AND WILDHORSE SUBSHEDS

LEGAL	REACH	DEFINABLE CHANNEL	RIPARIAN COMMUNITY	PERIODICITY	CONDITION	RISKS
			HEADWATERS OF THE WILLIAMSON RIVER SUBSHED			
T33SR11ES9	WRMR1	Y		EPH	PFC	A
T33SR11ES9	WRMR2	N		EPH	PFC	
T33SR11ES14/15	WRMR3	N		EPH	PFC	
T33SR11ES23/24	WRMR4	N		EPH	PFC	
T33SR11ES24	WRMR5	Y	MD19-11	INT	PFC	A
T33SR11ES18/19	WRMR6	Y	HQM1-21	INT	PFC	A
T33SR11ES24	T24AR1	N		INT/PER	PFC	
T33SR11/12ES19/24	T19AR1	N		EPH	PFC	
T33SR11/12ES24/25	T25AR1	N		EPH	PFC	A
T33SR11ES13/14	T13AR1	Y	GM41-12	INT	PFC	A
T33SR11ES14	T14AR1*	Y	MD19-11	INT	PFC	A
T33SR11ES9/10/11	T11AR1	N		EPH	PFC	
T33SR11ES11/12	T18AR1	N		EPH	PFC	
T33SR11ES12	T18AR2	N		EPH	PFC	
R33SR11/12S12/12/18	T18AR3	N	CLM1-12	INT	PFC	A
T33SR11ES7/12	T7AR1	N		EPH	PFC	
T33SR11ES12	T12AR1	N		EPH	PFC	
T33SR11/12ES6/12	T12AR2	N		EPH	PFC	
T33SR11ES1/2	T2AR1	?		?	?	?
T33SR11ES3/4	T36AR1	N		EPH	PFC	A
T33SR11ES2/3	T36AR2	N		EPH	PFC	A
T33SR11ES3	T25BR1	N		EPH	PFC	

*Area contains sensitive plant species: Calochortus longebarbatus

LEGAL	REACH	DEFINABLE CHANNEL	RIPARIAN COMMUNITY	PERIODICITY	CONDITION	RISKS
			WILDHORSE CREEK SUBSHED			
T33SR11ES6/7	T35AR1	Y		EPH	PFC	
T33SR11ES7/18/19	T35AR2	Y		EPH	PFC	
T33SR11ES9/30	T35AR3	Y	CLM2-11	INT	FAR	A,G
T33SR10/11ES36/25	T35AR4	Y		EPH	PFC	A
T33SR10ES35/36	T35AR5	?				
T33SR10ES1/36	T1AR1	N		EPH	PFC	A
T34SR10ES1/2	T1AR2	N	SALIX	INT	PFC	
T33SR10ES35	T35BR1	N	CLM2-11	INT	PFC	A,G
T33SR10ES35	T35CR1	N	GM41-12	INT	PFC	A,G
T33SR11ES29	T29AR1	Y	MD19-11	INT	FAR	A,G
T33SR10/11ES25/30	T25CR1	Y	GM41-12	PER	FAR	A,G
T33SR10/11ES7/24	T24AR1	Y		EPH	FAR	A
T33SR10ES12/13	T13AR1	Y		EPH	PFC	

REACH DESIGNATION: e. g. T11BR2DRI

T11	-	Tributary with headwaters in section 11
B	-	Indicates this is the second tributary originating in section 11
R2	-	Reach number two in upstream direction from confluence of next larger tributary
D	-	Definable (D) channel as opposed to an Undefined (U) channel
R	-	Indicates an in-channel Riparian (R) plant community as opposed to a Non-riparian (N) plant community
I	-	Intermittent (I) as opposed to Ephemeral (E) or Perennial (P)

FUNCTIONAL CONDITION

PFC	-	Proper Functioning Condition
FAR	-	Functional At Risk
U	-	Upward Trend
D	-	Downward Trend
NA	-	Trend Not Apparent
NF	-	Non-Functional

AT-RISK FACTORS COMMONLY ENCOUNTERED

A	Road activity contributing negatively
B	Presence of Active Headcuts
C	Side bank erosion
D	Side slope erosion
E	Presence of Increaser/Invader vegetative species
F	Loss of Riparian Zone/Floodplain
G	Past Logging Activity
H	Manmade Diversions/Channelization
I	Mixed effects from past Erosion Control Structures

ANALYSIS OF CHANNELS IN THE HEADWATERS AND WILDHORSE SUBSHEDS

Assessment of the following systems was made by examining all accessible road crossings. Any systems with a channel defined by more than a litter layered low area were examined more closely to determine classification and riparian component if present. All length and slope values have been determined from USGS Quadrangles. All the systems listed were rated as PFC or FAR. The most common risk factor appears to be the number of road crossings and only a small fraction of those are visibly contributing negatively to the stream channels. One other risk factor that commonly occured was the effects of past logging activity. Many of the cuts examined extended up to and through existing or once existing stream channels. It is not clearly evident whether removal of shade and disregard for existing stream channels, during logging operations, has caused the loss of or a change to a drier riparian plant community in some systems.

T1AR1 (T33/34SR10E) This .39 mi. reach originates from Willow Pond and continues across forest road 410 downstream to its confluence with T35. Map calculated slope is 1.13%. Channel is mostly undefined, non-riparian, and ephemeral. This reach does contain a segment that is riparian. This segment extends from the 410 road west to the channel origin. This area consists of a dense salix community. No surface water is present but the water table is very near the surface. Possibly the result of the 410 road acting as a compression dam and hindering ground water flow beyond its limit. System appears to be in proper functioning condition. RISKS: 410 road xing.

T35AR1 (T33SR11E) This 1.02 mi. reach extends from its sub-out point in sec. 6 upstream to the confluence of T35 and T24, just north of the Williamson River Highway. Map calculated slope is

1.05%. Channel is mostly defined, non-riparian, and ephemeral. In places recent vehicle traffic is evidenced directly in the channel.

T35AR2 (T33SR11E) Reach is 2.57 mi. in length and extends from the confluence with T24 vic. of the Williamson River Highway upstream through sec.18 and 19 to confluence with T29. Map calculated slope is 1.74%. Channel is well defined with a pebble to cobble substrate. Braiding takes place where the channel becomes less confined between side slopes. There is no riparian plant community and the system is classified as ephemeral. System is in proper funtioning condition with no apparent risks other than possible upstream activities.

T35AR3 (T33SR11E) This 1.01 mi. reach extends from the confluence with T29 in sec.19 upstream to the 4592 road (vic. Wildhorse Spring). Map calculated slope is .84%. Channel is clearly defined and intermittent with a riparian plant community of (CLM2-11) lodgepole/bearberry. System could easily be classified as PFC but the 4592 road crossing is contributing excess sediment directly to the stream channel and sediment from the road crossing is evidenced appx. 100ft. downstream. Logging or firewood gathering operations in the area between this trib and the Wildhorse spring channel appear to be having a more detrimental effect on the riparian community than road conditions. System is rated FAR downward trend.

T35AR4 (T33SR10/11E) This 2.04 mi. reach extends from the 4592 road xing upstream to the confluence of T1. Map calculated slope is 2.19%. Channel is mostly defined, non-riparian, and ephemeral. Most of this system is in proper functioning condition. RISK: vehicle traffic from the 4592 road has utilized the channel in the upstream direction apparently during firewood gathering activities.

T35AR5 (T33SR10E) Unable to locate any definable channel for this tributary. Map calculatcd length .87 mi. and slope .15%.

T35BR1 (T33SR10E) This reach, as mapped, is .23 mi. long with a map calculated slope of .42%. Trib should be mapped at least to and more likely beyond the 330 road where there is no definable channel but a riparian community of (CLM2-11) lodgepole/bearberrry. Riparian vegetation presence indicates an intermittent system. System is in proper functioning condition but possible risks may include the 330 road xing and past logging activity.

T35CR1 (T33SR10E) This reach, like T35B, should be mapped at least to or beyond the 330 road xing. It is currently mapped as being .28 mi. in length with a .14% slope. Channel is undefined and intermittent with a riparian plant community of (CLM2-11) lodgepole/bearberry. System is in proper functioning condition again with possible risks from the 330 road xing and past logging activity.

T29AR1 (T33SR11E SEC 29) This intermittent reach is .85 mi. long from its confluence with T35A upstream to its origin. Map calculated slope is 1.0%. Channel is defined and a riparian plant community of (MD19-11) Poa cusickii exists. System is functioning at-risk. Risk factors include the 460 road xing and, more importantly, past logging activity.

T25CR1 (T33SR10/11E SEC25/30) This unmapped reach originates at Wildhorse Spring and joins T35AR3 appx. .25 mi. downstream from the 4592 road xing. Channel is well defined, riparian (GM41-12 Elymus glaucus), and perennial. Channel morphology is similar to T35AR3. System was still flowing water up to but not beyond the confluence with T35A in mid August 95. System appears to be in proper functioning condition but there is some very noteworthy gullying taking place down the 4592 road and contributing sediment directly to the channel. Also, logging or firewood gathering activities between T25 and T35 are having negative effects on the riparian community.

T24AR1 (T33SR10/11E SEC 7/18/24) This reach is 2.41 mi. long with a map calculated slope of 3.2% It extends from its confluence with T35A upstream across the Will. Riv Hwy. to its origin in Sec. 24. Channel is mostly undefined, non-riparian and ephemeral except just upstream from the Williamson River Highway. Here more of a riparian plant community is evident but likely the result of water being held back for a longer period of time by the highway. System is rated as functioning at risk. This tributary is crossed by forest roads at least 7 times throughout its length and past logging activity has occured up to and through the existing channel.

T13AR1 (T33SR10E SEC12/13) This reach extends from its origin near the jct. of forest road 055 and the Will. Riv. Hwy. to its sub-out point at the southwest corner of Deer Draw. Map calculated length and slope is 1.11 mi. and 4.49%. Channel is mostly defined, non-riparian, and ephemeral. System is in proper functioning condition with the only risks possibly posed by the 4590 and 020 road xings.

WRMR1 (T33SR11E SEC 9) This reach extends from the private property boundry near the Head of the River Campground upstream to the confluence of T11A. Map calculated length is .75 mi. and slope is 2.19%. Channel is defined, non-riparian and ephemeral. System is rated as properly functioning.

WRMR2 (T33SR11E SEC 9) This reach extends from the confluence of T11A upstream to the 44 road xing. Length .47 mi. and slope 3.65%. Channel is mostly undefined, non-riparian, and ephemeral. Proper functioning condition.

WRMR3 (T33SR11E SEC 14/15) This reach extends from the 44 road xing upstream to the confluence of T13A. Map calculated length is 1.62 mi. and slope is 1.75%. Channel is mostly undefined, non-riparian, and ephemeral. Proper functioning condition.

WRMR4 (T33SR11E SEC 14/23/24) This reach extends from the confluence of T13A upstream to the confluence of t25A in Sec 24. Map calculated length is 2.38 mi. and slope is .68%. Channel is mostly undefined, non-riparian, and ephemeral. Proper functioning condition.

WRMR5 (T33SR11E SEC 24) This reach extends from the confluence with T25A upstream to the confluence with T19A (vic. Bottle Spring). Map calculated length is .81 mi. and slope is .82%. Channel is defined, riparian (MD19-11 Poa cusickii), and intermittent. Despite some disturbance via the 110/170 road xing near the stock pond in Sec 24 and activity in the meadow, this system is in proper functioning condition.
NOTE: There is a reach extending north from the meadow above the stock pond in Sec 24 that is unmapped. Channel is undefined, but a (CLM2-11) lodgepole/bearberry riparian community exists.

WRMR6 (T33SR11/12E SEC 18/19/24) This reach extends from the confluence with T19A (vic. Bottle Spring) upstream to its origin above an unnamed spring in Sec 18. Map calculated length is 1.14 mi. and slope is 1.49%. Channel is defined, riparian (HQM1-21 Aspen/Elymus glaucus) and intermettent. Rated as properly functioning but risks posed again by road xings (4650, 100, and an unnamed road).

T13AR1 (T33SR11E SEC 13/14) This reach extends from its confluence with WRMR3 upstream to its origin in Sec 13. Map calculated length is 1.08 mi. and slope is 2.35%. Channel is mostly defined, riparian (GM41-12) and intermittent (more so in the upstream direction). Proper functioning condition RISKS: 110 road xing.

T14AR1 (T33SR11E SEC 14) This reach extends from its confluence with T13A upstream to its origin Map calculated length is .77 mi. and slope is 3.2%. Channel is mostly defined, riparian (CLM2-11) and intermittent. An unmapped stock pond exists on the upstream side of the 110 road xing in a meadow. Meadow consists of (MD19-11) Poa cusickii with Calochartus longebarbatus (sensitive plant species). System is in proper functioning condition. RISKS: 110 road xing.

T25AR1 (T33SR11E SEC24/25) This reach extends from its confluence with WRMR4 upstream to its origin in Sec 25. Map calculated length is 1.17 mi. and slope is 1.13%. Channel is mostly undefined, non-riparian and ephemeral. Proper funcitoning condition. RISKS: 4652 road xing.

T19AR1 (T33SR11/12E SEC19/24) This reach extends from its confluence with WRMR5 upstream to its origin in Sec 19 (vic. Pelican Reservoir). Map calculated length is 1.07 mi. and slope is 1.24%. Channel is mostly undefined, non-riparian and ephemeral. Proper functioning condition.

T11AR1 (T33SR11E SEC 9/10/11) This reach extends from its confluence with WRMR1 upstream to its origin in Sec 11. Map calculated length is 1.37 mi. and slope is 3.04%. Channel is mostly undefined, non-riparian and ephemeral. Proper functioning condition.

T18AR1 (T33SR11E SEC 11/12) This reach extends from its sub-out point in Sec 11 upstream to the confluence with T12A. Map calculated length is .93 mi. and slope is 1.22%. Channel is undefined, non-riparian, and ephemeral. Proper functioning condition.

T18AR2 (T33SR11E SEC 12) This reach extends from the confluence with T12A upstream to the confluence with T7A. Map calculated length is .37 mi. and slope is 2.38%. Channel is undefined, non-riparian, and ephemeral.

T18AR3 (T33SR11/12E SEC 12/13/18) This reach extends from the confluence with T7A upstream to its origin in Sec 18. Map calculated length is 1.05 mi. and slope is 1.03%. Channel is mostly undefined, non-riparian and ephemeral however, there are intermittent, riparian inclusions of (CLM2-11) lodgepole/bearberry, specifically at the border of Sec 13/18 where the channel nears the 223 road. Proper functioning condition.

T7AR1 (T33SR11E SEC 7/12) This reach extends from its confluence with T18A upstream to its origin in Sec 7. Map calculated length is .57 mi. and slope is .76%. Channel is undefined, non-riparian, and ephemeral. Proper functioning condition.

T12AR1 (T33SR11E SEC 12) This reach extends from its confluence with T18A upstream to its origin in Sec 12. Map calculated length is .14 mi. and slope is 2.71%. Channel is undefined, non-riparian and ephemeral. Proper functioning condition.

T12AR2 (T33SR11/12E SEC6/12) This reach extends from its sub-out point in Sec 12 upstream to its origin in Sec 6. Map calculated length is .86 mi. and slope is 4 83%. Channel is undefined, non-riparian and ephemeral. Proper functioning condition.

T36AR1 (T33SR11E SEC3/4) This reach extends from Yamsey Springs area (Head of the River Campground) upstream to the confluence with T25B. Map calculated length is 1.39 mi. and slope is 3.15%. Channel is mostly undefined, non-riparian and ephemeral. Downstream from the 4648 road the channel does become more defined and some riparian vegitation is present. Proper functioning condition. RISKS: at least 4 different road xings.

T36AR2 (T33SR11E SEC 2/3) This reach extends from the confluence with T25B upstream to the private property boundry in Sec 2. Map calculated length is 1.52 mi. and slope is 4.55%. Channel is undefined, non-riparian and ephemeral. Proper functioning condition. Only apparent risks may be posed by road xings (at least 4).

T25BR1 (T33SR11E SEC 3) This reach extends from its confluence with T36A upstream to the private property boundry in Sec 3. Map calculated length is .54 mi. and slope is 4.05%. Channel is undefined, non-riparian and ephemeral. Proper functioning condition

APPENDIX

E

Williamson River Subsheds Acres & Miles of Road Summary			
Subshed	Acres	Miles of Road	Miles of Road Per Square Mile
Bear Creek	7,186	20	1.81
Big Springs Creek	28,948	56	1.24
Cottonwood Creek	12,823	67	3.30
Deep Creek	6,738	17	1.59
Desert Creek	42,857	97	1.45
Dillon Creek	7,758	65	5.42
Haystack Creek	13,485	97	4.62
Hog Creek	48,205	281	3.75
Jack Creek	59,962	336	3.57
Jackson Creek	12,692	65	3.25
Long Prairie	15,348	122	5.08
Lost Creek	12,633	70	3.50
Miller Creek	36,803	109	1.88
Mosquito Creek	18,010	109	3.89
Pothole Creek	6,789	33	3.00
Pumice Desert Basin	8,935	2.5	0.18
Sand Creek	10,508	70	4.35
Scott Creek	11,873	70	3.68
Shoestring Creek	30,109	234	4.98
Silent Creek	10,925	63	3.71
Sink Creek	14,569	47	2.04
Skellock Creek	22,014	166	4.88
Spring Creek	16,449	119	4.58
The Bull Pasture	17,828	148	5.29
Wild Horse Creek	18,360	165	5.69

Williamson River Subsheds Acres & Miles of Road Summary			
Subshed	Acres	Miles of Road	Miles of Road Per Square Mile
Williamson above Lake	29,672	202	4.39
Williamson above Marsh	50,139	323	4.14
Williamson above Sprague	49,555	354	4.60
Williamson above marsh	11,940	78	4.11
Williamson Headwaters	14,360	88	4.00
Williamson Vic of Marsh	228,373	854	2 39
Yoss Creek	16,204	74	2.96

APPENDIX

F

A SHORT HISTORY OF WILLIAMSON RIVER HABITAT IMPROVEMENT PROJECTS

The following information was provided by Tom Neal, representing Klamath Flycasters; John Fortune, ODFW Fish Biologist; Chris Hescock and Jay Frederick, Biologists on the Chiloquin Ranger District, Winema National Forest.

1973

The Royce Tract was obtained by the Winema National Forest through land exchange. This afforded the opportunity for riparian and instream fish habitat improvement.

1974

Upper Williamson River -- Royce Tract

Project: Tree and shrub planting in fenced exclosures (400 shrubs, including poplar, willow, aspen, and Chinese elm on both sides of one mile of stream).
Purpose: To provide shade along stream.
Cooperators: ODFW, USFS, KCFC (Klamath County Flycasters), Boy Scouts.
Success: Largely a failure because the plots were too far above the water table.

1975

Spring Creek (tributary to Lower Williamson River)

Project: Placement of 300 yards of spawning gravel behind gabion.
Purpose: To develop additional spawning habitat for trout.
Cooperators: ODFW, OSPD.
Success: Excellent, trout began using the area in November of 1975.

Upper Williamson River -- Royce Tract

Project: Continuation of tree and shrub planting begun in 1974. (A total of 1200 trees and shrubs were planted and protected by wire cages in 1974 and 1975.)
Purpose: Provide stream shading.
Cooperators: ODFW, USFS, Mazama Flycasters. 40 person hours.
Success: Poor because of low water table. Approximately 35% survived after one year. Native vegetation responded well where cattle were excluded.

1976

Upper Williamson River

Project: Fenced 1/2 mile of stream upstream from Rocky Ford to exclose cattle.

Purpose: To allow for riparian/stream rehabilitation and improve fish habitat.

Cooperators: ODFW on USFS
Success: Good, showing slow recovery, has suffered from trespass cattle grazing.

1977

Upper Williamson River

Project: Riprap eroding streambanks on Royce Tract. Lodgepole pine trees placed parallel to the banks. 150 willows and 50 aspen shoots planted along stream edge.
Purpose: To slow velocity and capture sediment.
Cooperators: ODFW, USFS
Success: Partial. Some protection and rehabilitation. Problems with beavers stripping limbs off trees and eating planted willows and aspen shoots. Trespass cattle caused problems and reduced success.

1978

Spring Creek (tributary to Lower Williamson River)

Project: Placed 50 yards of gravel in channel. Added 200 yards of gravel to gabion.
Purpose: To probide new and better spawining habitat for trout.
Cooperators: ODFW, OSPD, KCFC may have helped purchase gravel.
Success: Excellent. Heavily used by large spawning trout.

1979

Spring Creek (tributary to Lower Williamson River)

Project: Placed 60 yards of gravel instream.
Purpose: To enhance trout spawning habitat.
Cooperators: OSPD, Winema NF, FFF, ODFS, KCFC
KCFC: 5 persons for 30 person hours
FFF, ODFW: $500 toward purchase of gravel
Success: Excellent.

1980

Spring Creek (tributary to Lower Williamson River)

Project: Placed 50 yards of gravel in stream.
Purpose: Provide additional spawning habitat.
Cooperators: ODFW, KCFC
KCFC: 10 persons for 50 person hours.
ODFW: gravel purchased in 1979.

Success: Excellent.

1981

Upper Williamson River -- Royce Tract

Project: Placement and anchoring to banks of 52 lodgepole pine trees.
Purpose: To deflect flow from eroding banks and provide cover for trout.
Cooperators: ODFW, USFS
2 days
Success: Fair. Provided bank protection, enhancing riparian recovery and providing cover for fish.

1984

Spring Creek (tributary to Lower Williamson River)

Project: Placement of 96 yards of gravel.
Purpose: Enhance spawning habitat for trout.
Cooperators: ODFW (STEP), OSPD, KCFC
7 persons for 54 person hours, $264 donations to KCFC for purchase of gravel.
Success: Excellent.

1986

Upper Williamson River -- Royce Tract

Project: Planted willow wattles and stakes along waterline.
Purpose: To establish and accelerate streamside cover.
Cooperators: ODFW, USFS, Klamath Tribe (KT), KCFC
KCFC: 8 persons for 64 person hours>
Success: Minimal. Very little survival of plantings due to beaver activity and frost heave.

1987

Upper Williamson River -- between Sand Creek Ranch and Deep Creek

Project: Placement of 325 trees along 1.7 miles of stream.
Purpose: To accelerate rehabilitation of stream and improve fish habitat.
Cooperators: ODFW, USFS, YCC, KT, KCFC.
KCFC: 125 person hours.
Success: Excellent. Structures deflecting current and trapping sediment, narrowing stream and providing fish cover.

Spring Creek (tributary to Lower Williamson River)

Project: Placement of 3 log sills with gravel.
Purpose: To enhance trout spawning habitat as mitigation of brown trout die-off as a result of fire retardent drop in stream.
Cooperators: ODFW, YCC, KCFC
ODFW, YCC: approx. 28 person hours
KCFC: 14 person hours
USFS: Funding for gravel purchase through KV funds from fire salvage sale.
Success: Good.

Upper Williamson River -- Deep Creek area

Project: Continuation for tree placement in the Deep Creek area on 0.8 miles of stream.
Purpose: To narrow stream channel and provide better cover.
Cooperators: ODFW, YCC, USFS, KCFC
ODFW, YCC: approx. 80 person hours
KCFC: 8 members participated, 40 person hours
USFS:
Success: Excellent, working as intended.

Lower Williamson River -- Larkin Creek to Collier State Park

Project: Placement of boulders, trees, and trees with root wads.
Purpose: To provide instream cover.
Cooperators: ODFW, USFS KCFC, Roy Hauck Construction
ODFW: approx. 80 person hours
KCFC: 40 person hours
USFS:
Roy Hauck Construction: Hauled trees from HWY 97 right of way construction to streamside.

Upper Williamson River -- Royce Tract and other portions

ODFW, KT, and Winema NF enter into cooperative monitoring effort which consists of 8 river cross-sections recording velocity, depth, and width; and 24 photo points to determine changes in the river system. The report will be due in the year 2000.

<u>1989</u>

Lower Williamson River -- mouth or Kirk Canyon

Project: Placement of 35 yards of gravel in spring areas.
Purpose: To enhance trout spawning.
Cooperators: ODFW, YCC, USFS, KCFC
ODFW, YCC: approx. 40 person hours

KCFC: 20 person hours
USFS:
Success: Good. Spawning trout were observed using the gravel by early November, 1989.

Lower Williamson River -- Williamson River Campground

Project: Placement of 25 yards of gravel in streambed. Accomplished in November.
Purpose: To enhance trout spawning.
Cooperators: ODFW, KCFC
ODFW: approx. 120 person hours
KCFC: 60 person hours

Upper Williamson River -- Royce Tract

Project: Placement of 50 additional trees. This is the last project work in this area, future effort will be to monitor (see 1988).
Purpose: Streambank stabilization, instream cover.
Cooperators: USFS, ?
USFS: Tractor used to uproot and place trees.
? : Pickup with winch used to help place trees.

1990

Upper Williamson River -- Sand Creek Ranch downstream 2 miles

Project: Removal of old fencing, repaired exising fences and gates. Constructed 400 feet of new drift fence. Accomplished in July.
Purpose: Clean up streamside area. Fence constructed to protect spring area.
Cooperators: ODFW, KCFC
ODFW: approx. 120 person hours
KCFC: 60 person hours

1991

Mainstem Williamson River -- Kirk Canyon

Project: Install 10 yards of river-washed gravel in main and side channels.
Purpose: Enhance spawning habitat for salmonids.
Cooperators: USFS, ODFW
Success: Not determined.

1993

Upper Williamson River -- Rocky Ford Crossing

Project: Construct 1.8 miles of smooth wire "New Zealand" livestock fence along east side of river. Fence approximately 200 feet from river.
Purpose: Inhibit livestock use of riparian area or create riparian pasture, depending on current political direction.
Cooperators: USFS, ODFW, KCFC
Success: After first year, maintenance level appears low. Fence effectively inhibits livestock tresspass.

1994

Upper Williamson River

Project: Contruct 1.0 mile of smooth wire livestock fence along east side of river. Fence approximately 400 feet from river. Construct sites for recreational access to river (4).
Purpose: Inhibit livestock use of riparian area.
Cooperators: USFS
Success: Not determined.

Bottle Spring -- Upper Williamson Watershed

Project: Construct 1.6 miles of smooth wire livestock fence around meadow.
Purpose: Regulate livestock use of riparian meadow; protect high quality source o ground water to upper Williamson River.
Cooperators: USFS
Success: Not determined.

APPENDIX

G

Tributary Streams of the Williamson River Basin

ASPEN CREEK

1979 ODFW survey notes indicate cooler river temperatures just downstream of Aspen Creek. This may indicate subterrainial flow from Aspen Creek into the river. Aspen Creek appears to be diverted into a series of irrigation ditches that eventually join Deep Creek. It is doubtful that fish passage is possible. Most of Aspen Creek lies on private land. Habitat on Forest Service land should be surveyed, and the presence of lamprey or other fish investigated. Aspen Creek is mysteriously small for the size of its watershed, which is of a similar magnitude as Deep Creek. Surface flow appears to be less than ten percent of Deep Creek. There may be some geological explanation for this. Currently Aspen Creek appears too small, even upstream of diversions, to offer fish habitat. Several small springs (approximately 20 gallons per minute flow) were observed on an outside bend of the river near where Aspen Creek joined as a dry ditch.

DEEP CREEK

This is the only tributary perennially connected to the river. Sediment transport to its alluvial fan may risk the perennial aquatic connection to the river. The consequences to sensitive species such as the possibly existent Miller Lake lamprey, of cutting this tributary off from the river are unknown, but potentially very significant. Weyerhaeuser biologists electrofished Deep Creek during the fall of 1995, finding an abundance of brook trout and some redband trout up to at least Yamsay Camp at NE/SE S21. Darryl Gowan (USFS, personal communication) observed several redband trout of 150-180mm in length near the FS road 4648 crossing.

A 1995 level II stream survey indicates channel incision on USFS land at T31S, R11E, S31 SW/NW. Photographs accompanying the survey indicate a Rosgen "C" type channel with a wide, shallow wetted channel that potentially could pose passage problems to spawning runs of fish. This survey was not conducted on adjacent private property in sections 31 and 32. Because of the importance of the private reach at the lower end of the stream, it should be resurveyed, if permission can be obtained from the owners of Deep Creek Ranch.

It is possible the redband trout observed in Deep Creek were juveniles escaping predation and competition from larger fish in the river. They may also be seeking cooler water that Deep Creek offers. Larger fish could be space and forage limited in Deep Creek. Rainbow trout spawn in the river upstream of Sand Creek from mid January into March. A spawning ground survey of Deep Creek during this period would reveal if Deep Creek is utilized for spawning, and whether the fish are a headwater (live in Deep Creek throughout their lives) or adfluvial (spawn in Deep Creek but live in the river the rest of the time) form. Outmigrant traps would also indicate spawning. Survey photos indicate potential quality spawning habitat in T31S, R11E, S29 SW1/4. If barriers to spawning runs are discovered, they should be modified to provide passage. If redbands were precluded from spawning habitat by modifiable barriers, then brook trout, which were introduced during the early 1930's, should be eradicated in order to eliminate potential interspecific competition, and maximize the effectiveness of spawning and early rearing habitat provided by Deep Creek. This would not eliminate brook trout from the upper Williamson river, but would give the redbands a head start in Deep Creek.

If spawning does occur in Deep Creek, these fish are potentially reproductively isolated from the redbands that spawn in the Williamson River. It is possible the Deep Creek redbands represent a headwater stock, or a reproductively isolated adfluvial form that is genetically distinct from the redbands that spawn in the river. Unique genetic traits might be identified via electrophoretic or meristic differentiation. It is not known where the upper Williamson redbands sampled by Buchanan (1994) spawn, but future samples of juveniles from Deep Creek could be compared to samples from the river for genetic differences.

Deep Creek enters the river as two channels. The main channel enters the river at the northwest corner of section 31. Both channels appear to be natural, but the south channel is apparently a constructed diversion ditch (Darryl Gowan, USFS, personal communication). A cooperative investigation should be conducted with the owners of the Deep Creek Ranch to study possible consolidation of these channels This would be provided that the combined channels might enhance redband spawning and rearing habitat in the upper Williamson watershed by increasing summer flow and habitat volume in the main creek channel and reducing stream temperature

HEAD OF THE RIVER SPRING

The Head of the River Spring supplies water to the Yamsay Ranch reach, which is dammed and pretty well cut off from the lower river approximately 1.5 river miles upstream of Wickiup Springs. Brook trout and presumably some redband trout inhabit this reach. Very little information is available for this private reach. There may be little or no exchange of fish with the rest of the river. Numerous smaller springs exist along this reach.

Aerial photos indicate the dams on this reach have trapped a great deal of sediment, and have created large shallow ponds where water warms during the summer.

IRVING CREEK

This creek is also diverted above the river. USFS data indicates flow rates of 1-2 cubic feet per second. This small spring fed system would provide cool water refuge to the river and possibly some limited spawning habitat due to its small size.

JACKSON CREEK

Jackson Creek is potentially the largest tributary stream of the upper Williamson River, but the stream is now totally diverted before it joins the river. Area residents have said there was never a single channel that joined the river; instead the creek swamped out as it does today. Instead of joining the river as one surface channel that would provide significant benefit to the aquatic biota of the river, water from Jackson Creek likely joins the river as groundwater over an extended area. During spring runoff the confluence area floods and forms a lake like connection between the two streams. This may have occurred during redband spawning season during the reference era, but information is lacking. Taking into consideration the Government Land Office survey notes taken during October 1892 in this vicinity (refer to Modoc Creek discussion below), it is well within the realm of possibility that Jackson Creek had an aquatic connection to the Williamson during wet climate cycles. In this event Jackson Creek would have provided a primary spawning area for trout during the reference era. A population of redband trout spawning in Jackson Creek would not necessarily spawn at the same February to March interval as the population that spawn on the Sand Creek Reef.

Jackson Creek has potential as spawning habitat for redbands. According to Plumie Wright (a long time area resident), the confluence area with the river traditionally held adult redband trout during the summer. Currently, brook trout inhabit the lower 4 miles of Jackson Creek. The creek was electrofished from 1990-92 by the Klamath tribe, ODFW, and USFS. Only brook trout were found. USFS notes indicate brook trout were stocked in 1931, and rainbow trout in 1947.

Since redband trout have been found in Deep Creek (see below), it is logical there were redbands in Jackson Creek when, or if, it had a connection to the river. The life history of Jackson Creek stock could have been either adfluvial, fluvial, or headwater in nature. The larger size of Jackson Creek would tend to provide viable spawning substrate for larger adfluvial forms of trout. Since brook trout appear to be the only remaining fish in Jackson Creek, they may have a competitive advantage over any redbands stranded there that had either the adfluvial or fluvial strategy of life history.

MILLER LAKE AND MILLER CREEK

This is the only natural lake in the watershed. Once the home of the Miller Lake lamprey, an endemic species to the watershed, Miller Lake was chemically treated in an attempt to improve the sport fishery in 1964. The uniqueness of the lamprey was discovered several years later by Dr. Carl Bond at Oregon State University. Recent sampling of immature lamprey ammocoetes further down in Miller Creek has raised the possibility of the survival of this species. Pending positive identification of the lamprey, management activities that may effect the Miller Creek drainage should be very conservative.

Early observers of the lake in the late 1800s included Judge John B. Waldo and a USGS survey crew. Both groups visited before fish stocking activities began near the turn of the century. In his diaries Waldo frequently mentioned the number, species and size of fish caught at each lake. Actually the only types of fish mentioned were trout. The dairy entry for Miller Lake (then known as Fish Lake) only mentions eating breakfast and leaving. USGS surveyors noted the lake abounded with fish, but also failed to mention particular species. It is known that the lamprey and tui chub existed here, but no mention of salmonids prior to stocking. Possibly Waldo and the surveyors were less than enthusiastic to report they dined on chubs. However, if chubs and lamprey gained access to the lake from lower in the watershed, the lake would be accessible to trout as well. If trout did not naturally occur in the lake, it might be explained by the lack of a sizable spawning stream that would preclude access for larger fish such as redbands that might grow too large to reach spawning gravel in Evening Creek where brook trout currently spawn.

There is no evidence of successfully reproducing brown trout in the lake; they are maintained by Oregon Department of Fish and Wildlife stocking. Kokanee in the lake spawn near the shorelines. Tributary inlets and seeps or springs along the shore need to be protected as fish bearing where they are associated with spawning habitat. It may be possible to eliminate the need for further brown trout stocking if the predatory fish species were changed to shore spawning lake trout. Brown trout do have the recreational fishing advantage of being more available in shallow water.

There has been concern for human use of Miller Lake causing eutrophication. This is much less likely than most lakes because Miller Lake's bathymetry being narrow and deep as opposed to more vulnerable shallow lakes such as nearby Diamond Lake on the Umpqua National Forest. Shallow lakes recycle nutrients much more efficiently than narrow deep lakes. Miller Lake has been known to have a brief blue-green algae bloom, but this is a function of warm surface water produced by years with a warm dry climate and the naturally high phosphorus levels associated with watersheds in this region. Blue-green algae can fix atmospheric nitrogen when waters warm. Miller Lake is nitrogen limited, but blooms of blue-greens have been isolated rare events. Barring a major climate shift, blue-green algae do not represent a major risk to this system.

A primary area to monitor for early signs of eutrophication is the southeast end of the lake where it reaches roughly twenty to thirty feet in depth. There was an extensive weed bed here during the summer of 1996. The rest of the lake doesn't seem to produce nearly as extensive of a stand of aquatic macrophytes as this area. Summer afternoon upslope winds from the east push the surface waters back to the northeast end of the lake and allow relatively nutrient rich water to rise at the southeast end in response. At some depth this water receives enough light to produce rooted aquatic plants and suspended phytoplankton A significant expansion of this stand of plants likely indicates higher concentrations of limiting nutrients, specifically nitrogen, in the water. Monitoring by placing markers at the shallower extent of the plant stand is an easy and casual method to monitor fluctuation of vegetation. Phytoplankton can also respond with a bloom thus shading rooted vegetation and reducing or eliminating the stand. If this were to happen the bloom would be very obvious by the green translucent to opaque appearance of the water.

Woody debris along the shoreline and at the lakes outlet protect the lake from erosion and provide habitat for fauna associated with the lake. There is a lack of woody material in the vicinity of the campground. This condition should be brought back as close as practical to natural conditions.

MODOC CREEK

The modern Modoc Creek shows up as a vestigial channel across the valley bottom to the river. There is a possibility of an aquatic connection to the river during wetter climate cycles. In fact a Government Land Office (GLO) survey dated October 1892, and interpretation of the dry channel in current aerial photos, indicate a perennial aquatic connection to the Williamson in the form of a two foot wide channel. The perennial reach flows approximately 1-2 cfs currently. Modoc Creek would probably function similar to Irving Creek when connected to the river, except that the vast majority of the stream has a gradient greater than five percent, which would be considered too steep for trout to inhabit without assistance such as beaver ponding. Due to the historic aquatic connection, the lower reaches of Modoc Creek need to be treated as perennial fish-bearing habitat. The aquatic connection to the Williamson indicates a groundwater table at, or near, the surface at the confluence of these streams.

SAND CREEK (EAST)

Four tenths of a mile of Sand Creek lies on Forest Service property, starting 0.6 miles east of the channel's confluence with the river. Considering the five foot diameter culvert at the 4648 road crossing, it seems that large flows enter the river during runoff. Weyerhaeuser biologists surveyed several points along Sand Creek from mid October to early November of 1995. They reported no perennial reaches, and no standing water was observed. Mike McNeil, USFS (personal communication), observed flow into mid September of 1995 on some higher reaches. Considering that 1992 through 1994 was a drought period suggests the possibility that Sand Creek is functionally a perennial system, in particular reaches, during wet climate cycles rendering this system as "cyclically perennial". Flow rates for June through August 1992-94 were 68, 91 and 70 percent of average over the past 21 years. Climatologists claim Oregon has also been in a twenty year dry cycle up to this point. According to Steve Koon, Sand Creek has been flowing to the river since December of 1995 through late spring 1996. If beaver inhabited the high meadow area around King's Cabin, then associated stream reaches would be more perennial in nature. It may be that Sand Creek is cyclically perennial, and it possibly could supply spawning and early rearing habitat to the upper Williamson system during wet climate cycles. Mr. Koon has recently observed brook trout and possibly dace in Sand Creek.

Sand Creek appears to be a flashy system with an abundance of cobbles and boulders. It may provide spawning substrate to the river at its confluence. Aerial photos indicate a potential spring at the mouth of the creek that may provide critical habitat, thus Sand Creek is important for the maintenance of possible springs, as well as providing what is probably a sizeable contribution to the upper Williamson aquifer. Being a flashy system Sand Creek would augment spring floods and store additional water across the flood plain of the river This would be important in maintaining the hydrology and biology of the river.

If past timber harvest practices and overstocked forests prove to have reduced summer streamflow, Sand Creek may have been a perennial system much more often than not during the reference era.

The majority of the creek is a narrow canyon high gradient system (5%+) that is most likely inhospitable for beaver colonization (Olson and Hubert, 1994). The wider, low gradient, meadow system above the canyon section would probably support beaver, which could develop perennial reaches for fish refuge.

Monitoring channel and sediment stability of Sand Creek will benefit the Williamson River watershed by identifying problem areas such that mass sediment transport can be minimized, while maintaining recruitment of spawning gravel to the river. Because of the possible perennial nature of Sand Creek during future wet cycles, it should currently be treated as perennial fish bearing habitat.

SAND CREEK (WEST)

Characteristically Sand Creek is fairly typical of the cascade streams in this watershed. It becomes more important when its direct contribution to the marsh is considered. This is the only cascade stream that has a chance of a surface connection to the marsh during the reference era. Direct evidence of this alleged connection is lacking, but GLO maps from the 1890s show the creek ending in a swamp in sections 22 and 23 of T31S R8E. Modern maps show small springs and a small channel extending from a close point south of section sixteen and continuing to the marsh. A surface connection would create the possibility of spawning habitat in the stream for fish from the marsh. Even without a connecting channel this stream delivered high quality groundwater to the marsh and developed critical refuge habitat for trout in that section of the marsh. Together with Big Springs and the Williamson, Sand Creek created critical cool water habitat that would very likely sustain trout in the marsh. While the Williamson and Big Springs delivered more water than Sand Creek, Sand Creek has produced 20 to 70 cubic feet per second during wet years recently. Dry years in 1992 and 1994 have reduced flows to approximately 5 to 10 cfs. All this water is now diverted down the Sand Creek canal and its fate is questionable. If the Williamson and Big Springs were reconnected to the southern area of the marsh, it would be very beneficial to reconnect Sand Creek as well. No evidence of endemic fish were found for Sand Creek which would have been effective proof of an aquatic connection during the reference era.

Exotic brown, rainbow and brook trout have been planted in Sand Creek with brown and brook trout dominating the stream. They reproduce but attain a very modest adult size since the cascade streams exhibit low productivity. Their reproductive success indicates at least the potential for spawning habitat for marsh reared redband trout despite the high amount of fines prevalent in the volcanic substrate.

SHEEP CREEK

This stream has a perennial stretch but no channel close to the river. Its gradient is also mostly greater than five percent. Its value as fish habitat is probably more of a supporting role for the upper Williamson aquifer.

WICKIUP SPRINGS

Aerial photo analysis indicates Wickiup Springs as the primary source of water for the river downstream of the Yamsay Ranch. The photo indicates channel widening beginning approximately one river mile upstream of Wickiup in the NE/NW of section 20; which is approximately 500 feet upstream (south) of the 17/20 section line. The channel widens further at Wickiup. It is assumed that the channel condition is relatively homogeneous through this section, and the widening is due to groundwater contribution from Wickiup and several smaller springs, and irrigation returns from the Yamsay ranch. Wickiup supplies important spawning habitat, as well as the majority of the river's flow. This may indicate the functional upstream end of the summer trout habitat.